Aquatic Enhancement
& Survey, Inc.

Aquatic Plant Management Plan 2007-2011

Big Turkey Lake

Lagrange, Steuben County, Indiana

Prepared for the Big Turkey Lake Association

February 25, 2008

Aquatic Enhancement
& Survey, Inc.
P.O. Box 1036
Angola, IN 46703

1-888-867-5253
260-665-8226
www.aquaticenhancement.com

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Executive Summary

Big Turkey Lake is a 450 acre kettle lake located in Steuben County Indiana. Big Turkey Lake is generally nutrient rich (eutrophic) and has moderate warm season water clarity. The shoreline of the lake is approximately 90 percent developed with single family homes and cottages. The Lake is fed at its south end by Turkey Creek and Dewitt Ditch and overflows through Turkey Creek along the northwest shoreline of the lake. Big Turkey Lake has a complex shoreline with several bays and islands. The public can gain access to the lake through an Indiana Department of Natural Resources (hereinafter referred to as IDNR) access ramp off of County Road S 1150 E in the lake's northwest corner. Residents and users who access Big Turkey Lake enjoy fishing, swimming, boating, skiing, and tubing in the waters of the lake. Big Turkey is a popular destination for fishermen and hosts several tournaments and bass club outings each season. The Big Turkey Lake Association has maintained its own Walleye Stocking Program with IDNR approval. The lake contains a diverse aquatic flora, but has been colonized by the non-native plants Curlyleaf pondweed *Potamogeton crispus* and Eurasian watermilfoil *Myriophyllum spicatum*. For several years these plants have impaired the aesthetic quality of the lake and provided a significant hindrance to the recreational activities of the lake's users. Aquatic pesticide applications have occurred on various parts of Big Turkey Lake for several years to reduce vegetation around boating, swimming, and docking areas enough to allow for reasonable use and keep the lake's populated shorelines aesthetically pleasing for residents. Aquatic plant control applicators have been hired by individuals, groups of property owners, or subdivisions in recent years. In the 2006 season the Big Turkey Lake Association sought cost-share assistance from the Indiana Department of Natural Resources to develop this Aquatic Plant Management Plan to address plant management on a lakewide basis and consolidate aquatic plant management under the direction of the lake association. The general purpose of this plan is to help the Big Turkey Lake Association and IDNR direct management efforts toward the following set of goals:

1. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3. Provide reasonable public recreational access while minimizing the negative impacts on plant, fish, and wildlife resources.

Aquatic plant surveys conducted according to IDNR protocol in July and August (Tier II aquatic plant sampling) showed Big Turkey Lake to have a diverse plant community, however the growth of the invasive exotic plant Curlyleaf pondweed was extensive in 2007 and Eurasian watermilfoil, a highly invasive exotic aquatic plant was found to have colonized several areas of the lake. To initiate effective lakewide plant management the Big Turkey Lake Association is advised to treat all areas of significant Curlyleaf pondweed growth in 2008 with an early season (April) treatment with Aquathol K herbicide. The early treatment may be able to successfully prevent reproduction of the Curlyleaf plants thus diminishing their numbers in later seasons. The Big Turkey Lake Association is also advised to initiate the chemical treatment of Eurasian watermilfoil with 2,4-D granular aquatic herbicide on areas of significant colonization to reduce or prevent the spread of this plant. This is especially important since much of the colonized area is in or near inlets and recently dredged areas at the lake's south end where inflowing currents and boat activity may promote the vegetative spread of milfoil fragments throughout the lake. Granular 2,4-D has been proven to provide cost-effective control of broadleaf aquatic plants like Eurasian watermilfoil and will likely provide more reliable control than liquid herbicide formulations near the lake's inlets where water movement can affect treatment efficacy.

Continued efforts at educating lake users about the spread and management of invasive aquatic plants are also recommended through the association meetings and newsletter. Because taking care of the Big Turkey Lake watershed will ultimately help to minimize aquatic plant problems on the lake, the Big Turkey Lake Association is advised to continue to address erosion along its tributary streams and throughout the watershed. Based on the growth area in 2007 a cost estimate of $12540.00 is provided for early-season treatment of Big Turkey Lake's Curlyleaf pondweed in 2008 (38 acres). An estimated 16 acres of Eurasian watermilfoil will need to be treated in 2008 at a cost of $6656.00 with allowance for retreatment if needed for an additional $6656.00. The total estimated cost for the recommended exotic aquatic plant control in 2008 is $25852.00. An update of this plan should also be produced, utilizing aquatic plant surveys and mapping to direct efforts in future seasons and track the health of the Big Turkey Lake plant community. The total estimated cost of the Plant Management Plan Update for 2008 is $5450.00. The total program cost estimate is $31302.00. If this program is fully funded by the IDNR Lake and River Enhancement Program in 2008 the Big Turkey Lake Association's cost-share portion would be $3130.00. The table below contains estimated plan costs for the 2008 through 2011 seasons.

●**Success Benchmarks:** 5% of littoral area or less in dense exotic plant growth. (post treatment) 5% or less occurrence of Curlyleaf and Eurasian milfoil in July Tier II Survey	**2008**	**2009**	**2010**	**2011**
Month/Activity				
April, Map Curlyleaf pondweed And Eurasian watermilfoil growth	1000.00	1000.00	1000.00	1000.00
April/May (H2O temp app. 55 F or soon after emergence) Treat Curlyleaf pondweed as needed (.5-1ppm Aquathol K)	12540.00	12540.00	12540.00	12540.00
May, Begin Eurasian treatments on main lake as needed	6656.00	6656.00	6656.00	6656.00
July, Eurasian retreatment or new area treatment as needed	6656.00	6656.00	6656.00	6656.00
July, Tier II Survey	1900.00	1900.00	1900.00	1900.00
As arranged, Public Meeting	350.00	350.00	350.00	350.00
October/November, Permit Meeting	200.00	200.00	200.00	200.00
December, Plan Update Document Due	2000.00	2000.00	2000.00	2000.00
Total Cost, Pesticide Applications	**$25852.00**	**$25852.00**	**$25852.00**	**$25852.00**
Total Cost, Consultant	**$5450.00**	**$5450.00**	**$5450.00**	**$5450.00**
Total	**$31302.00**	**$31302.00**	**$31302.00**	**$31302.00**

Actual exotic plant treatment areas should be adjusted during the 2008 season through on-site surveys of emerging growth. The Big Turkey Lake Association and IDNR should maintain the flexibility to adjust the management program on-the-fly in response to actual growth areas as lake plant growth can vary considerably from season to season. The Big Turkey Lake residents may wish to continue treatment of native plants or filamentous algae in priority areas as allowed by District Fisheries personnel as long as these treatments are consistent with the overall APMP goals. Consolidation of non-LARE treatment areas through the lake association may be helpful in optimizing treatment timing and effectiveness.

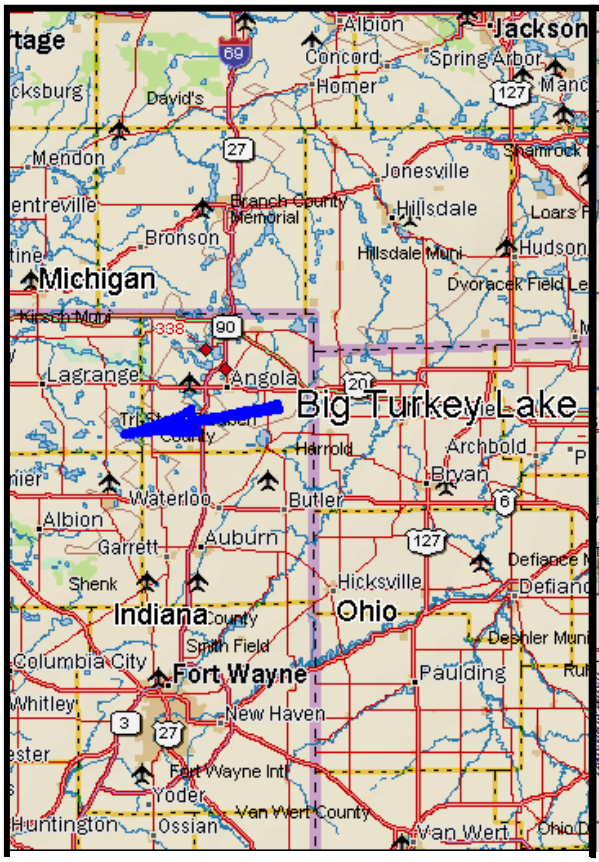


Figure 1 Big Turkey Lake General Location

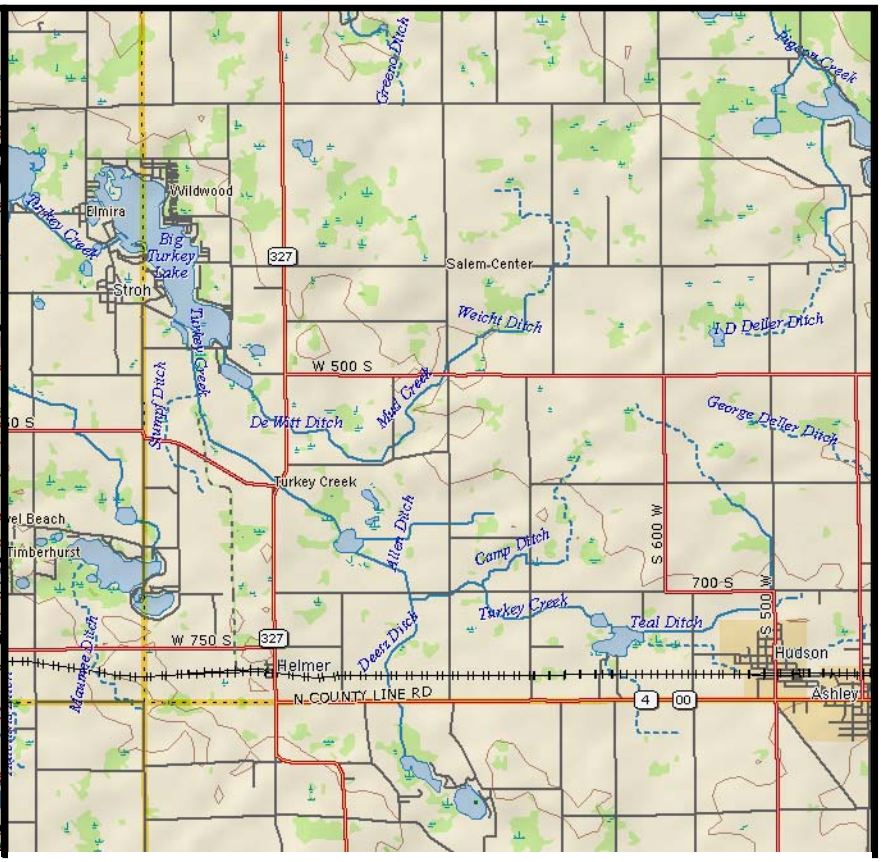


Figure 2 Big Turkey Lake and Surrounding Area

1.0 Introduction

Residents and users of Big Turkey Lake have noted problems with the excessive growth of aquatic vegetation in some areas of the lake. The invasive exotic plants Eurasian watermilfoil and Curlyleaf pondweed along with various native plants are commonly treated with aquatic herbicides in areas of Big Turkey Lake to reduce plant growth enough to allow for recreational use of the waters. With several subdivisions and private shoreline owners seeking plant control separately, plant management has been conducted in scattered areas without an overall plan in place to direct management efforts toward prudent goals on a lakewide basis. In the winter of 2006/2007 the Big Turkey Lake Association sought funds from the IDNR Division of Fish and Wildlife's Lake and River Enhancement Program to develop such a plan. This document is intended to help the Big Turkey Lake Association and IDNR direct plant management activities at Big Turkey Lake working toward the achievement of the earlier stated goals in the 2008-2011 seasons.

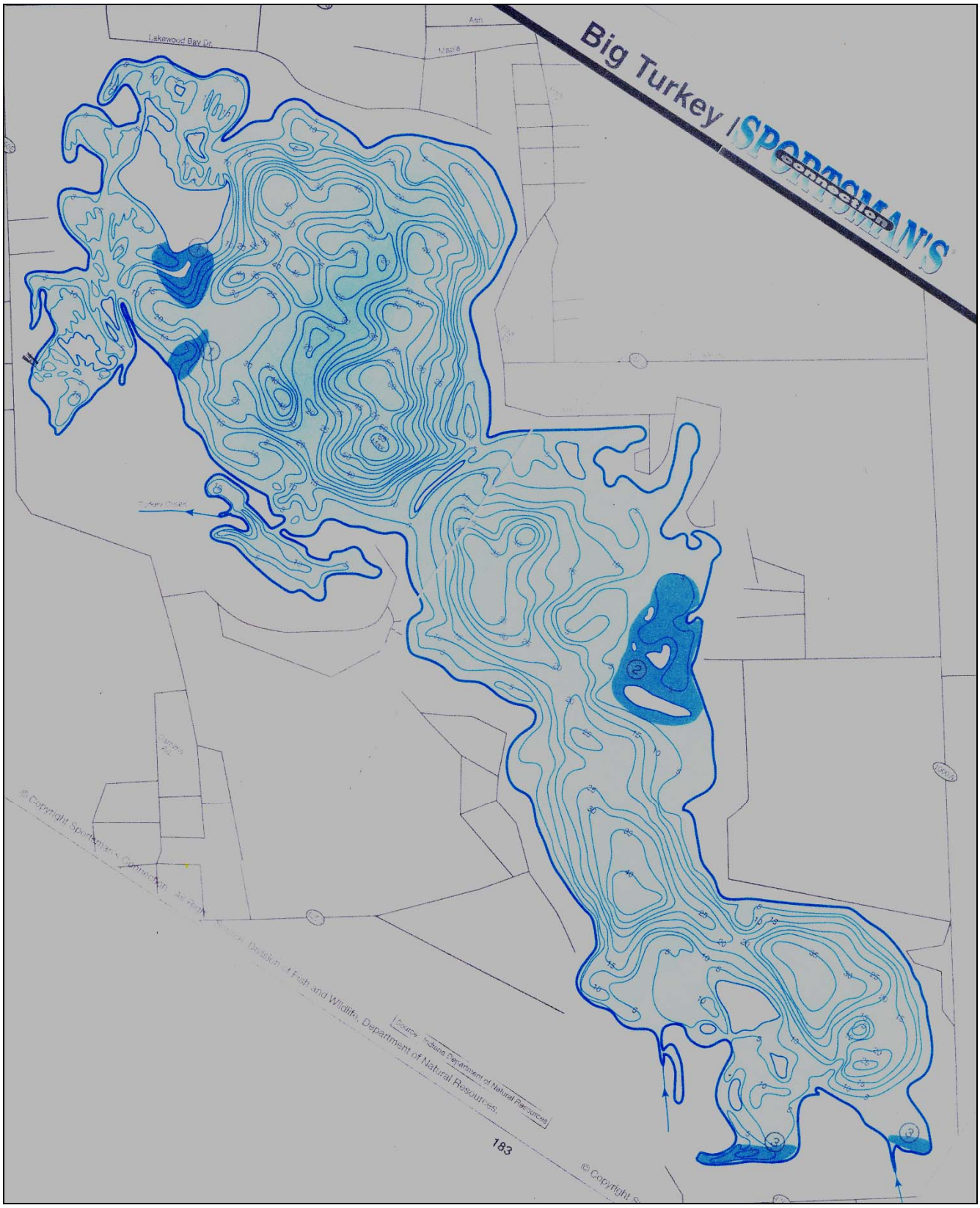


Figure 3 Contour Map of Big Turkey Lake, Source Sportsman's Guide, IDNR depth data

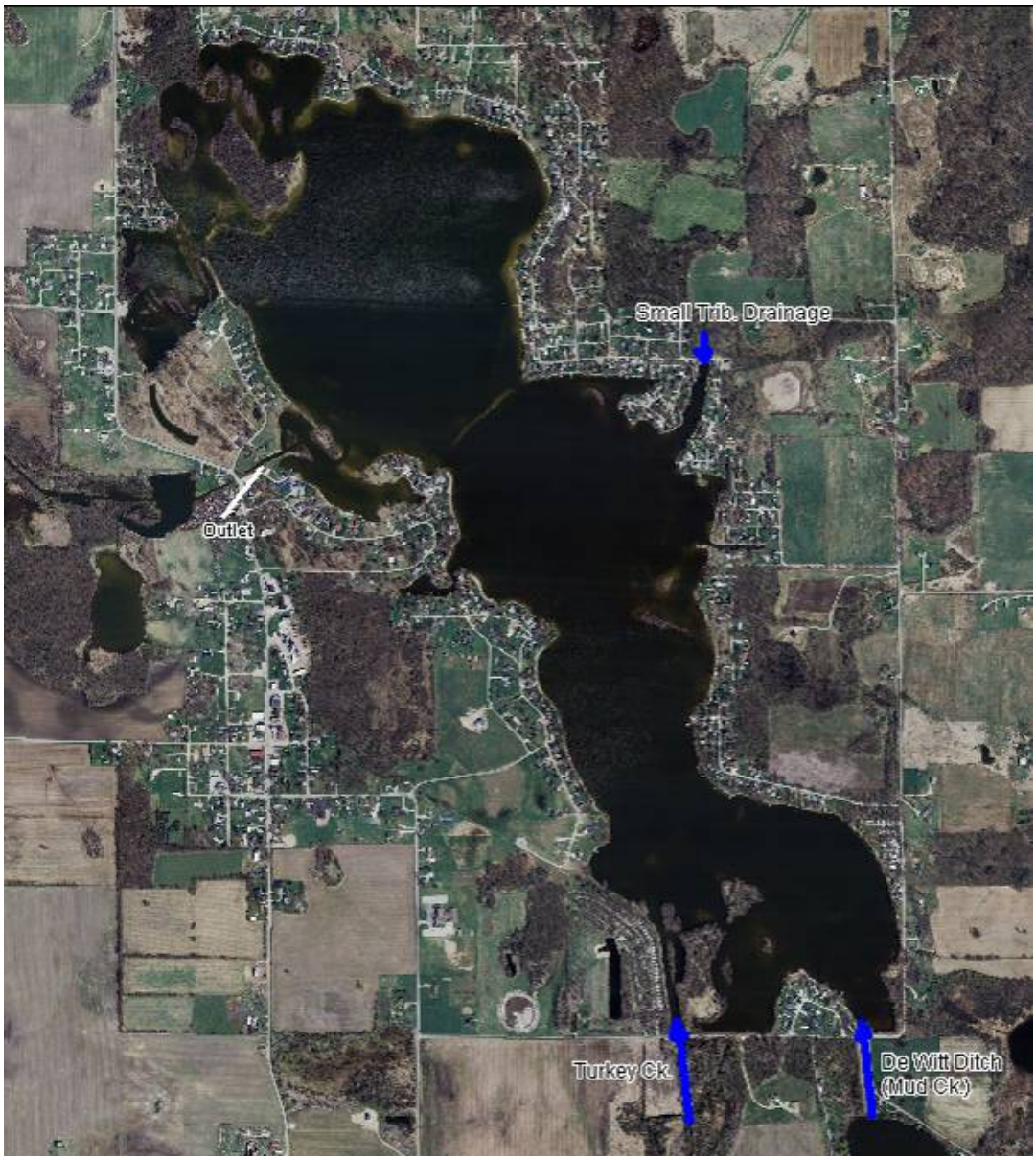


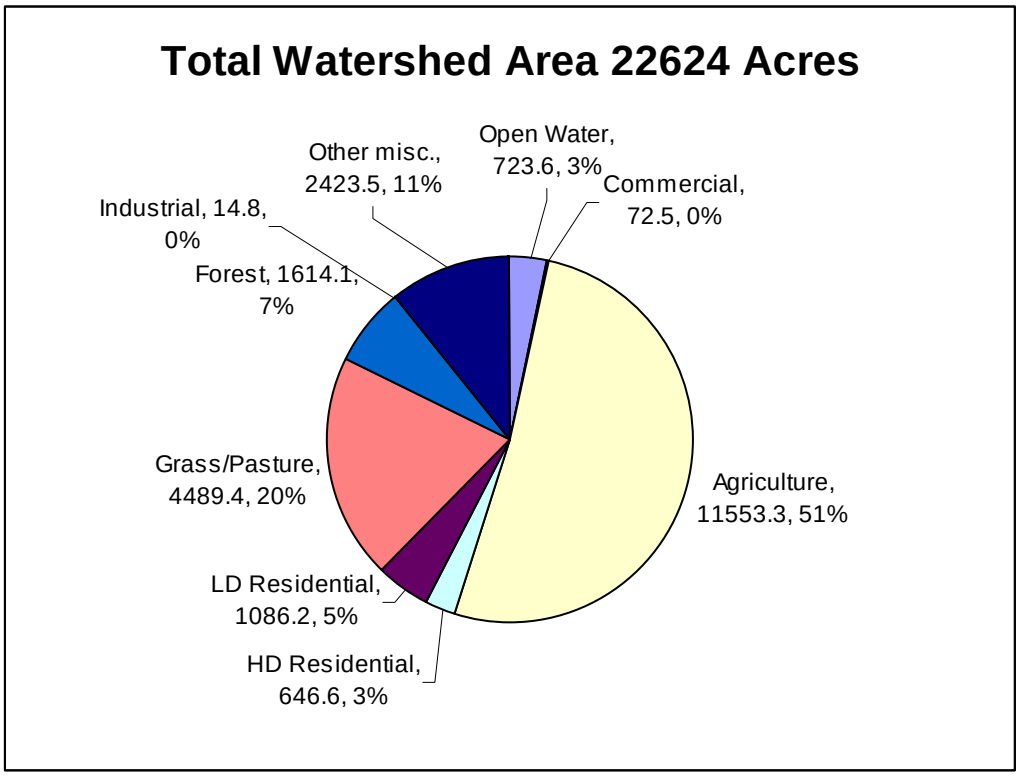
Figure 4 Air Photo of Big Turkey Lake

2.0 Watershed and Lake Characteristics

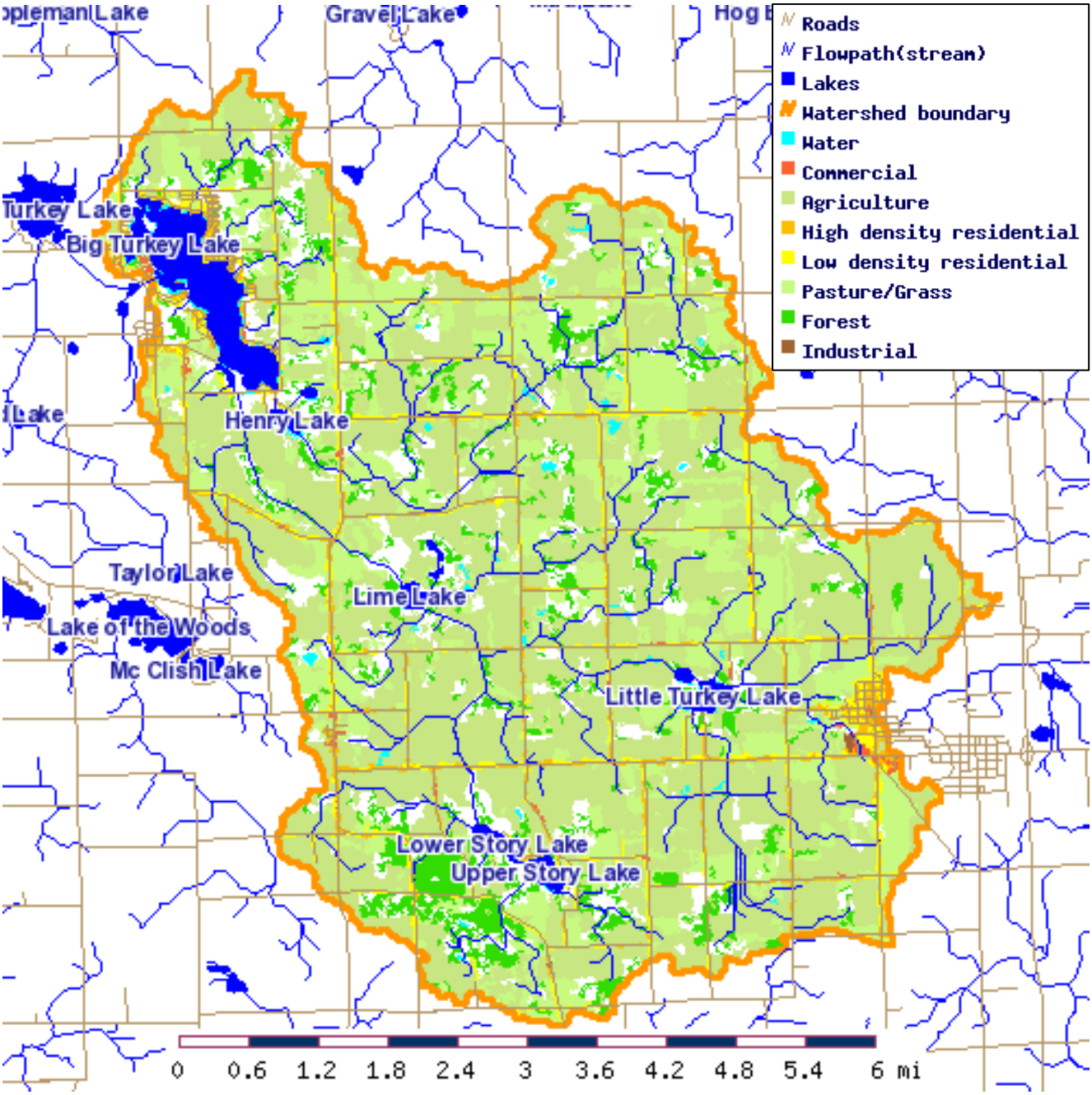
The shoreline of 450 acre Big Turkey Lake is approximately 90 percent developed with single family homes and cottages. The Lake is fed by Turkey Creek and Dewitt Ditch (Mud Creek) at its south end and drains through a bay in the northwest part of the lake to Turkey Creek. Big Turkey owes its eutrophic (nutrient rich) status to its large watershed of Approximately 22,624 acres (map 1 below). The hydraulic residence time of Big Turkey Lake's waters is approximately 114 days (Harza 1990). The watershed of Big Turkey Lake is mostly agricultural (51percent), but also contains significant pastureland (20 percent), residential areas (eight percent), and woodlands (seven percent) (see also map 1 and graph 1 below). The Indiana Department of Natural Resources has assisted the Big Turkey Lake Association with a number of projects to address nutrients and sediments entering from the watershed beginning with a feasibility study in 1990 (Harza 1990). The Harza feasibility study suggested six sites in the watershed as potential sites for wetland construction to form sediment traps. The study

recommended that a program of nutrient deactivation be initiated in Big Turkey Lake after construction of the sediment traps had reduced sediment and nutrient loads to the Lake. In 2002 the Big Turkey watershed was again looked at through a feasibility study funded by the Lake and River Enhancement Program (LARE) (J.F. New 2002). In the feasibility study six possible projects were evaluated and four were deemed feasible. Two of the projects, a bank stabilization along Dewitt Ditch, and hydraulic sediment removal at the mouth of Dewitt Ditch progressed through the design phase and were carried through to completion by the end of 2006.

Big Turkey Lake has a very complex shoreline with multiple islands, bays, and sandbars. Much of this complexity appears to be the result of marl dredging that took place at Big Turkey Lake in the early 20th century. The lakes bathymetry has also been enhanced by an old submersed railroad bed that forms a shallow sand bar bisecting the lake at its midsection. The varied bathymetry of Big Turkey Lake leaves wide littoral shelves with abundant plant growth in some areas but in others deeper water is located relatively close to shore (see figure 3 above). Nutrient inputs at the lakes south end appear to have created a much richer hydrosoil in the south half of the lake with abundant plant growth present, while some open areas in the north half of the lake are dominated by sandy or marly substrates with sparse plant growth. Closed bay and backwater areas at both ends of the lake tend to support luxuriant plant growth. Big Turkey Lake is generally nutrient rich (eutrophic) and has low to moderate warm season water clarity compared with many other northeast Indiana lakes. A Secchi depth of four feet was recorded in June of 2007 and 3.7 feet was noted in August of 2007. Property values have increased at Big Turkey Lake in recent years with an increase in the size of new homes being built. A new subdivision is currently being constructed, replacing a campground along an excavated channel/tributary inlet in the extreme southwestern corner of the lake.



Graph 1 Big Turkey Watershed Land Uses



Map 1 The Big Turkey Lake Watershed. Data and graphic from Agricultural and Biological Engineering, Purdue University Website

3.0 Lake Uses

With regard to swimming, fishing, and navigation nearly the entire developed shoreline of Big Turkey Lake can be considered "high use" (figure 5 below). Nearly all residents have watercraft and must navigate in and out of shoreline docking areas. Additionally several points act to constrain the flow of boat traffic into and out of the various bays. Two small dredged areas on each side of the sunken railroad bed that bisects the lake act to constrain the flow of traffic up and down the lake. The mid-section of this bar is much too shallow for normal watercraft passage. Noting these areas will be important both in preventing vegetative spread of fragmenting exotic plants and prioritizing areas for plant control.

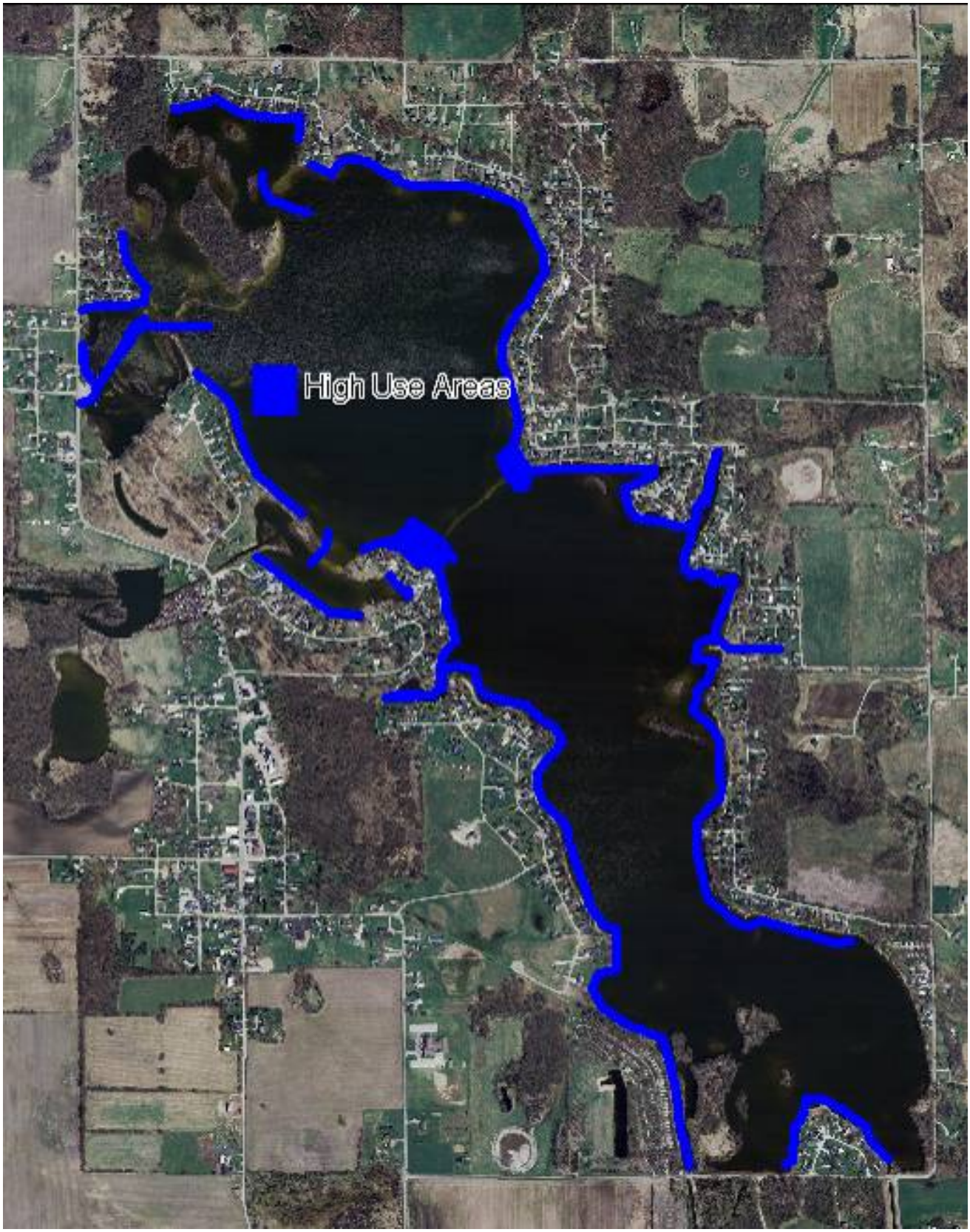


Figure 5 High Use Areas of Big Turkey Lake

SPECIES AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY NUMBER AND WEIGHT					
*COMMON NAME OF FISH	NUMBER	PERCENT	LENGTH RANGE (inches)	WEIGHT (pounds)	PERCENT
Bluegill	768	53.4	1.3 - 8.6	114.30	20.8
Largemouth bass	167	11.6	2.7 - 19.5	105.40	19.1
Warmouth	116	8.1	3.6 - 8.7	25.74	4.7
Pumpkinseed	85	5.9	3.5 - 7.7	10.64	1.9
Yellow perch	69	4.8	3.5 - 11.3	15.79	2.9
Walleye	40	2.8	7.6 - 24.9	67.80	12.3
Black crappie	39	2.7	4.6 - 11.0	11.85	2.2
Yelow bullhead	38	2.6	7.8 - 14.0	34.85	6.3
Hybrid sunfish	28	1.9	3.0 - 8.2	4.75	0.9
Golden shiner	20	1.4	5.1 - 9.2	2.26	0.4
Spotted gar	19	1.3	11.6 - 32.0	29.77	5.4
Brown bullhead	10	0.7	11.3 - 14.6	8.95	1.6
White sucker	9	0.6	13.7 - 19.1	17.47	3.2
Common carp	4	0.3	26.6 - 31.8	43.77	7.9
White crappie	4	0.3	11.0 - 13.7	2.81	0.5
Bowfin	3	0.2	23.9 - 27.3	17.85	3.2
Golden redhorse	3	0.2	16.5 - 18.3	5.63	1.0
Lake chubsucker	3	0.2	7.8 - 8.5	0.75	0.1
Northern pike	3	0.2	31.2 - 32.4	22.13	4.0
Redear	3	0.2	8.3 - 8.5	1.25	0.2
Starhead topminnow	2	0.1	2.0 - 2.1	0.02	**
Grass pickerel	1	0.1	10.4	0.22	**
Green sunfish	1	0.1	5.8	0.12	**
Log perch	1	0.1	4.2	0.03	**
Longnose gar	1	0.1	43.1	6.47	1.2
Brook silversides	present				
Total (26 Species)	1,437			550.62	

*Common names of fishes recognized by the American Fisheries Society.

Figure 6 Species, Length Ranges, and Relative Abundances of Fish Collected in the 2003 Season IDNR Fish Survey of Big Turkey Lake

4.0 Fisheries

Big Turkey Lake is well known as an area fishery. Several bass tournaments and bass club outings are held there each year. The lake is also known as an excellent bluegill fishery. The Big Turkey Lake Association stocked the lake with Walleye for several years (discontinued in 2006) and the Walleye showed good growth rates and added to the recreational fishery. The last IDNR fisheries survey for Big Turkey Lake was conducted in June of 2003. A total of 1437 fish representing 26 species were collected with a combination of gill-netting, trap netting, and nighttime D.C. electrofishing. The species and relative abundance list for the 2003 survey is in Figure 6 above. The survey report noted that the sportfish population in Big Turkey Lake was good; however aquatic vegetation was deemed to be a problem in the northern bays and along the southern shore. It was recommended that the lake association consider some type of vegetation control program in these areas. With regard to Big Turkey

Lake's fishery the growth of both native and non-native plants appears to be more than abundant enough to provide adequate cover and habitat. It's likely that significant aquatic plant control efforts can be maintained at Big Turkey Lake without detriment to the fishery as long as water quality is maintained and extensive treatment of native plants does not occur on a lakewide basis.

5.0 Problem Statement

Exotic plants can provide impairment to Big Turkey Lake directly and indirectly by out-competing the luxuriant growth of more beneficial native species for resources, contributing to a loss of diversity, impairing recreational use, and providing a complex habitat that can alter fish community functioning. Additionally the Eutrophic conditions of Big Turkey Lake can potentially be exacerbated if dense invasive vegetation is allowed to increase its area of colonization extensively and then managed by abruptly providing control in the later-season producing a nutrient rich situation where the plant community biomass is dominated by blue-green or filamentous algae.

6.0 Vegetation Management Goals and Objectives

The IDNR Division of Fish and Wildlife and LARE program staff have formulated three aquatic vegetation management goals that apply to Big Turkey Lake and other Indiana Lakes. The goals are as follows:

1. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species including a reduction in the transport of non-native aquatic plants to other lakes.

3. Provide reasonable public recreational access while minimizing the negative impacts on plant, fish, and wildlife resources.

Recommended management activities at Big Turkey Lake will be geared toward attainment of these goals and the following measurable benchmarks for success in that regard should be applied to Big Turkey Lake:

1. Limit the amount of the Big Turkey Lake littoral area in dense exotic plant growth to five percent or less.

2. Limit the occurrence of Curlyleaf pondweed and Eurasian watermilfoil in July Tier II sampling to five percent or less.

7.0 Plant Management History

While The Big Turkey Lake Association has not maintained an association sponsored plant management program, treatments have taken place in various parts of the lake to control Eurasian watermilfoil, Curlyleaf pondweed and a variety of native plants. These treatments have been sponsored at the subdivision level or by individual property owners or groups of property owners. The total treatment area in a given year has been less than 25 acres. Multiple treatments per season have been needed on many areas due to regrowth and the emergence of new plants in the post-treatment period. Areas that have received treatments for both native and exotic vegetation on Big Turkey in the last seven years are depicted on the lake map below.

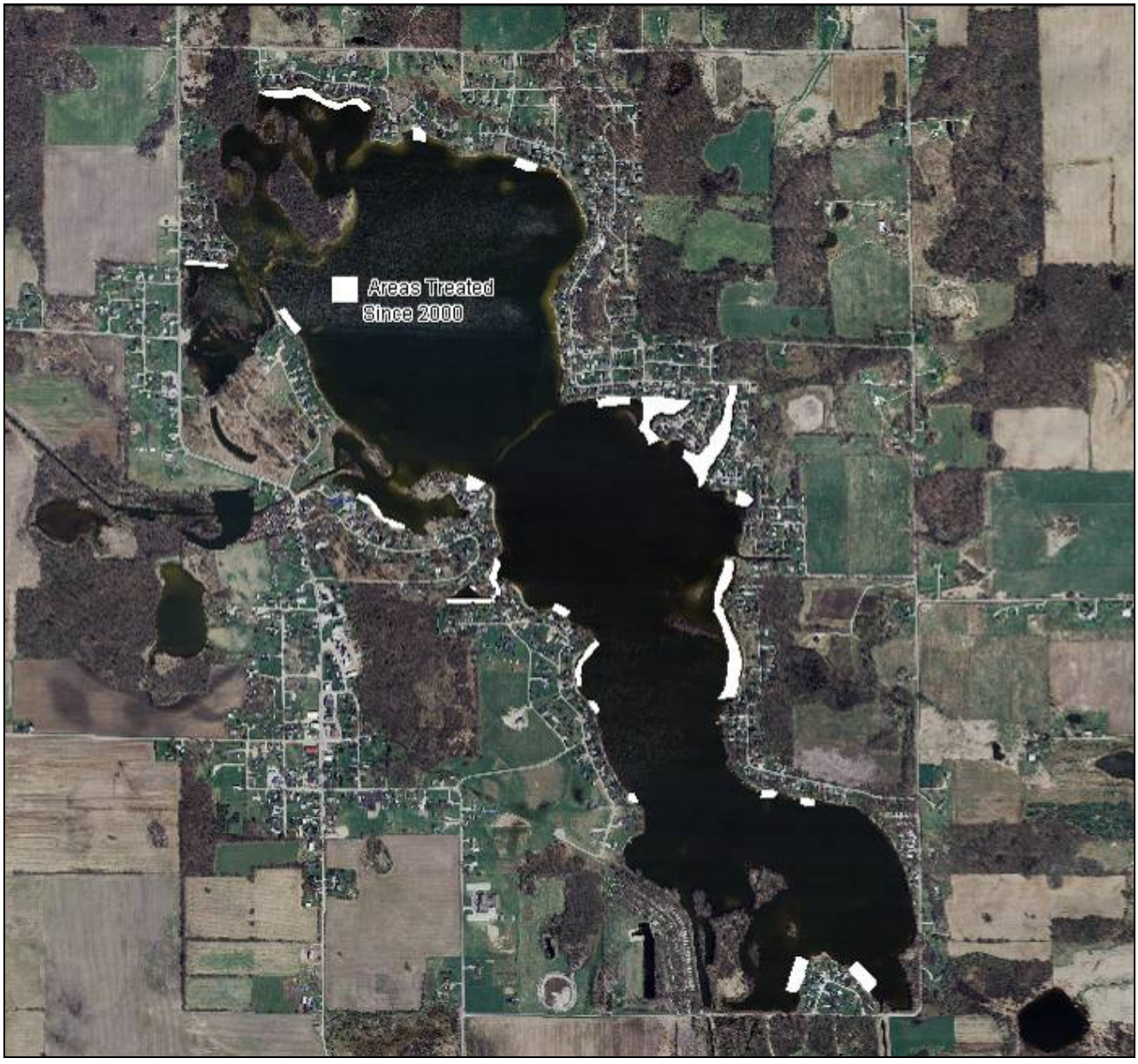


Figure 7 Areas of Big Turkey Lake Where Privately Sponsored Aquatic Plant Treatments Have Taken Place since the Year 2000

8.0 Aquatic Plant Community Characterization

8.1 Methods

Two primary methods of observation were used to characterize the lake's plant community during the 2007 season. Exotic plant beds were mapped mainly by visual observation. Extensive time was spent running a zigzag pattern over the lake's littoral zone to establish the boundaries for dense exotic plant growth. This was complimented by Tier II quantitative survey plant collection data and observation, prior knowledge of the lake's typical plant growth pattern, and a contour map. A handheld WAAS Enabled GPS unit was also helpful in marking the general boundaries of exotic plantbeds for mapping. To characterize the lake's plant community quantitatively and produce objective data for analysis and tracking of overall plant community composition, Tier II Plant surveys were utilized as described in the next section.

8.1.1 Tier II

Tier II stratified random sampling was utilized on June 9 and August 10 and 11 of 2007 to establish random plant sampling points and quantify approximate species biomass at each respective point. The Tier II aquatic plant sampling protocol used was established by INDR and is available in full in *Tier II Aquatic Vegetation Survey Protocol, May 2007* (IDNR 2007). In Tier Two sampling, data collection points are established within given depth strata of the lake according to lake size (450 ac. For Big Turkey) and trophic status (Eutrophic) listing. A toss and retrieval of a specially fabricated two sided rake (figure 8) on a rope is used to sample vegetation from the lake bottom at each point. After retrieval of the rake a score is assigned to each recovered plant species by separating the species and placing them back on the rake. The thickness of the plants when placed back on the rake is recorded as measured by equally spaced marks on the rake tines. This measurement assigns a rake score of one, three, or five to each species as a basic measure of biomass. Plants seen but not recovered on the rake are marked as "observed only". Filamentous algae is recorded only as "present" if recovered on the rake. Location data for sampling points was collected using a WAAS enabled GPS unit. Data points were then downloaded to geographic information system (GIS) software for placement on a map. Because aquatic plant species vary in their prominence during various part of the growing season sampling is performed in both the late and early season during plant plan development. In treatment seasons the two survey regime can also allow for a pre-treatment and post-treatment comparison of the lake's plant community. Data collected during the Tier II survey is then used to calculate a set of statistical descriptors developed by IDNR to help characterize plant communities in Indiana waters (Pearson 2004). The Tier II sampling points (80) for the early and late season surveys in 2007 are displayed in figures 9 and 10 below. According to IDNR protocol sampling was performed in Big Turkey Lake to a depth of 15 feet.

Figure 8 Tier II Plant Sampling Rake

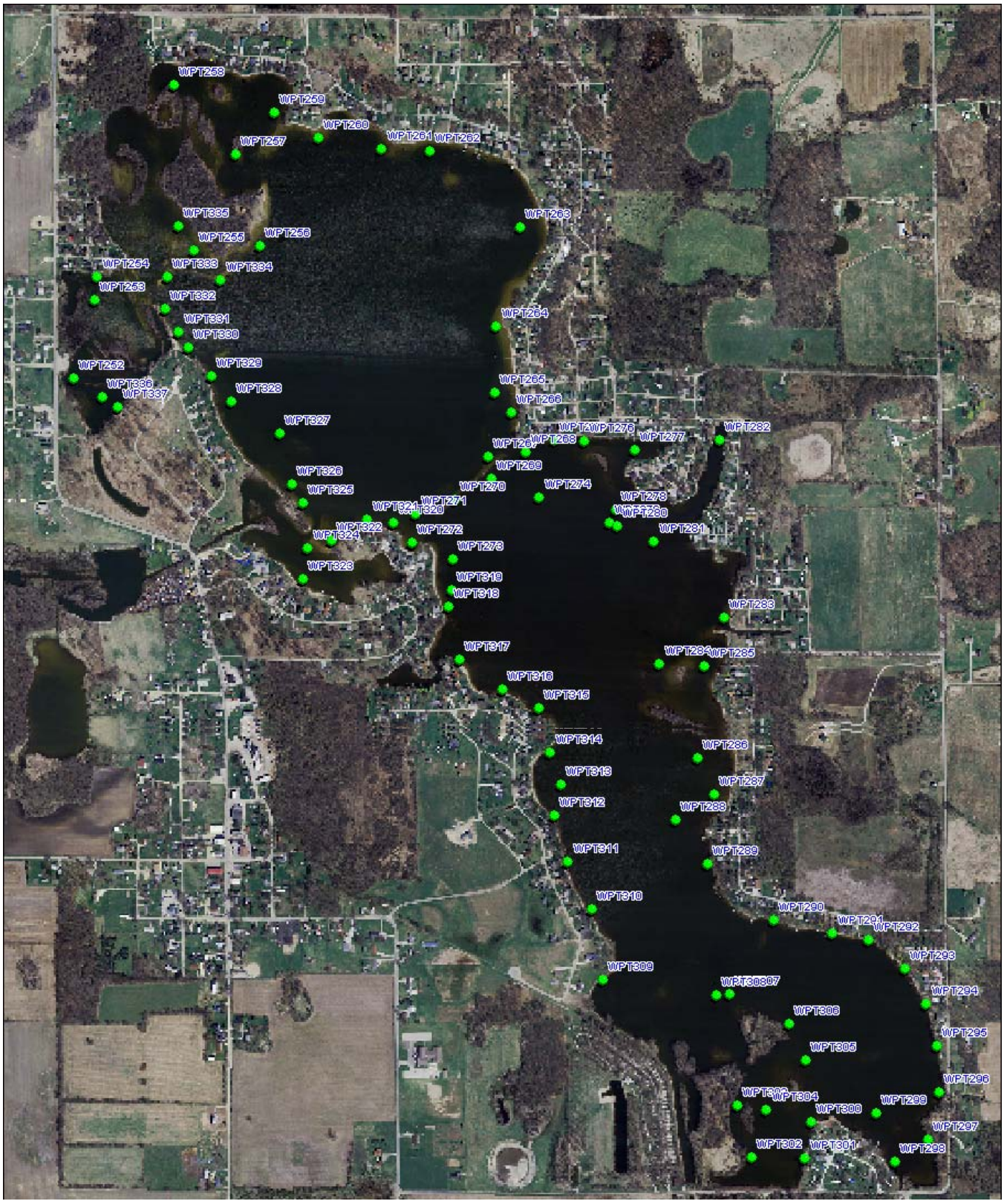


Figure 9 6/9/07 Tier II Survey Sampling Points for Big Turkey Lake

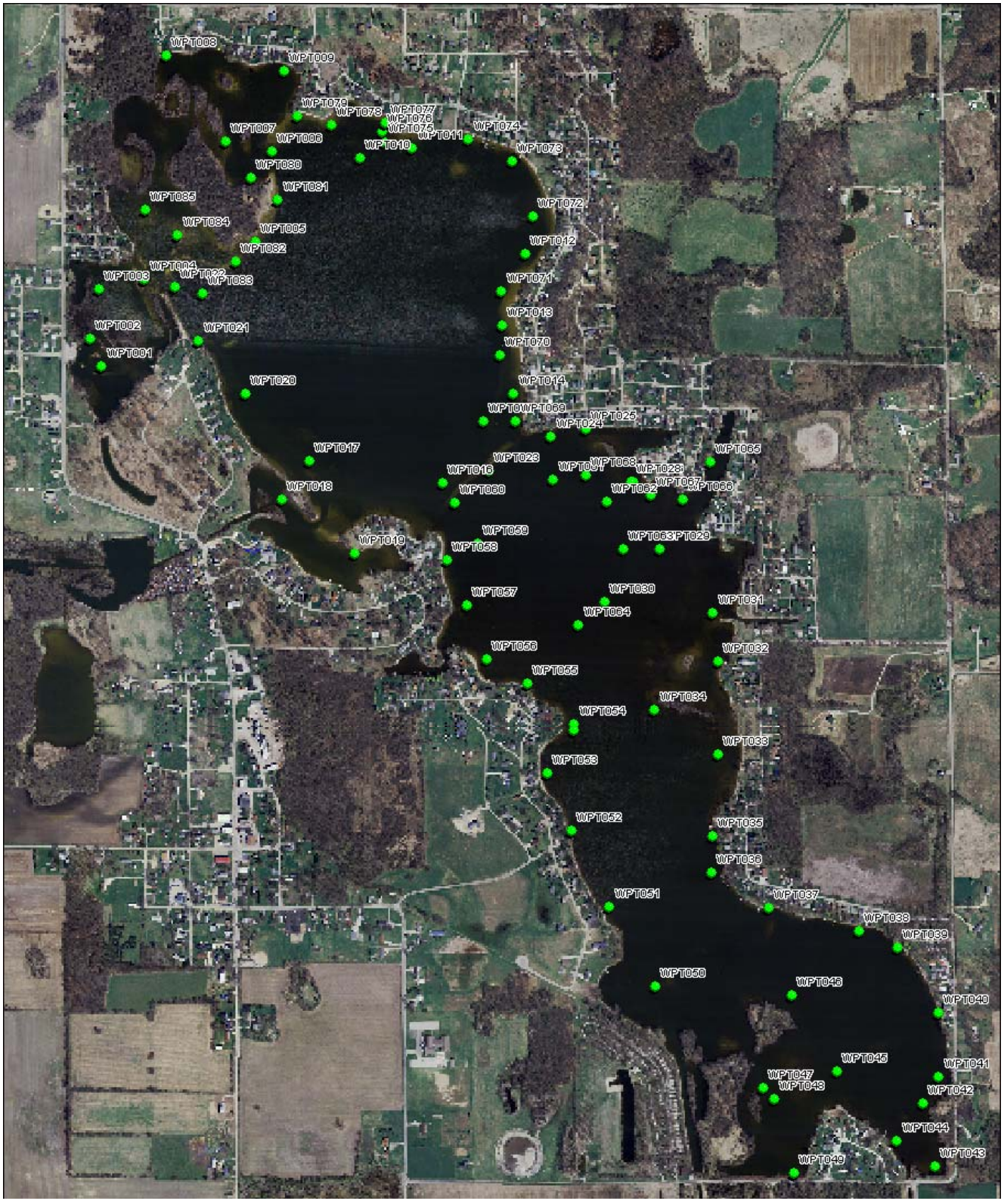


Figure 10 8/10, 11/07 Tier II Sampling Points for Big Turkey Lake

8.2 Results

Macrophyte Inventory Discussion

Exotic plant mapping in June of 2007 revealed a total of 41 acres of dense exotic plant growth (figure 11 below). The majority 25.54 acres was Curlyleaf pondweed growth. Areas of mixed Curlyleaf and Eurasian watermilfoil growth totaled approximately 15 acres and areas of Eurasian watermilfoil growth totaled 2.71 acres. The two tables below contain plant community descriptors for the early and late season Tier II surveys. Descriptors from a set of 21 other Indiana Lakes (Pearson 2004) are provided to provide insights as to how the Big Turkey Lake plant community compares to that of other Indiana Lakes. Tables 1-10 below show the tier II data including data specific to each five-foot depth contour zone. With 12 species noted, Big Turkey has significantly more species of plants than the average of eight for the 21 lake set. The number of native species, number of species per site, and Species Diversity Index are all above the 21 lake average showing a relatively diverse plant community for Big Turkey Lake. White-stemmed pondweed *Potamogeton praelongus* a state "threatened" species was observed growing in Big Turkey Lake in the 2007 season but no voucher specimen was collected. A specimen of this plant should be collected in 2008 to document its presence. White-stemmed pondweed has generally been noted along the western shoreline of the lake and along the railroad bed that bisects the lake. Backwater areas of beneficial native plant growth exist in the bays at the lake's northwest and south end. These areas are generally well protected by the speed limits in place. Plants were found growing to a maximum depth of 14.5 feet in the surveys. This gives Big Turkey a littoral (plant growing) area of approximately 163 acres.

Eurasian watermilfoil occurrence was a relatively mild five percent in both the early and late season surveys. The occurrence of Curlyleaf pondweed was very high, with Curlyleaf sampled at 37 percent of sites. It was the most common plant in the early season survey. Surprisingly even in the late season survey Curlyleaf (typically an early season plant) occurred at 27.5 percent of sites. From the Tier II data it appears that Curlyleaf has colonized Big Turkey to a much higher extent than Eurasian watermilfoil and probably presents a problem for lake users in many more areas. If a program of control for exotic plants is initiated at Big Turkey Lake it would be reasonable to establish a goal of holding total post-treatment exotic plant growth to 5% or less of the lake's littoral area. With regard to tier II data it would be reasonable to set a goal for Eurasian watermilfoil and Curlyleaf pondweed of five percent or less in late season sampling. Plant colonization patterns on Big Turkey Lake in general appear to be stratified in relation to the nutrient and sediment inputs from the lake's tributaries. Plant species preferring more nutrients or a richer hydrosoil appear in the sampling most often near the lake's South end with plants preferring intermediate habitat being most numerous around the lake's mid-section, and plants best suited to sandy/marly substrate (like Chara *Chara sp*.) most numerous at the north end. By number of occurrences Curlyleaf pondweed ranked first in the early season survey. Its distribution (figure 12 below) showed an affinity for areas enriched or disturbed by input from the lakes tributaries. Coontail *Ceratophyllum demersum* ranked second (fig 13) and showed a similar distribution. Variable watermilfoil *Myriophyllum heterophyllum* (fig 14) was third and did not show the affinity for the rich environment of the lakes delta areas as strongly, occurring commonly and thickly near the mid-section of the lakes shorelines. The sites where Eurasian watermilfoil were sampled were generally oriented toward the south end of the lake (fig 15). In the late season survey Coontail occurred most often again showing a high tendency to colonize delta regions heavily (fig 16). Spiny naiad *Najas marina* ranked second in abundance and showed the opposite distributional pattern preferring the sandier northern third of the lake, especially areas created or modified by marl dredging in the past (fig 17). Slender naiad *Najas flexilis* ranked third and tended to occur most heavily around the lake's mid-section (fig 18). Curlyleaf sites were more or less evenly distributed throughout the lake in the late season survey as were Eurasian watermilfoil sites (figs. 19 and 20). These patterns of colonization generally match the exotic plant mapping for 2007 and demonstrate the degree to which input from tributaries or disturbing activities such as dredging can shape Big Turkey Lake's aquatic plant community. This places emphasis on the fact that activities that address nutrient and sediment

sources in the watershed will be part of the overall plant management program. Projects such as the streambank stabilization on De Witt Ditch (Mud Creek) already completed by the Big Turkey Lake Association can help reduce plant problems in the long term while improving water quality/clarity on Big Turkey Lake. Other opportunities for wetland restoration or land treatment may exist in the watershed and should be an area of exploration for the Big Turkey Lake Association.

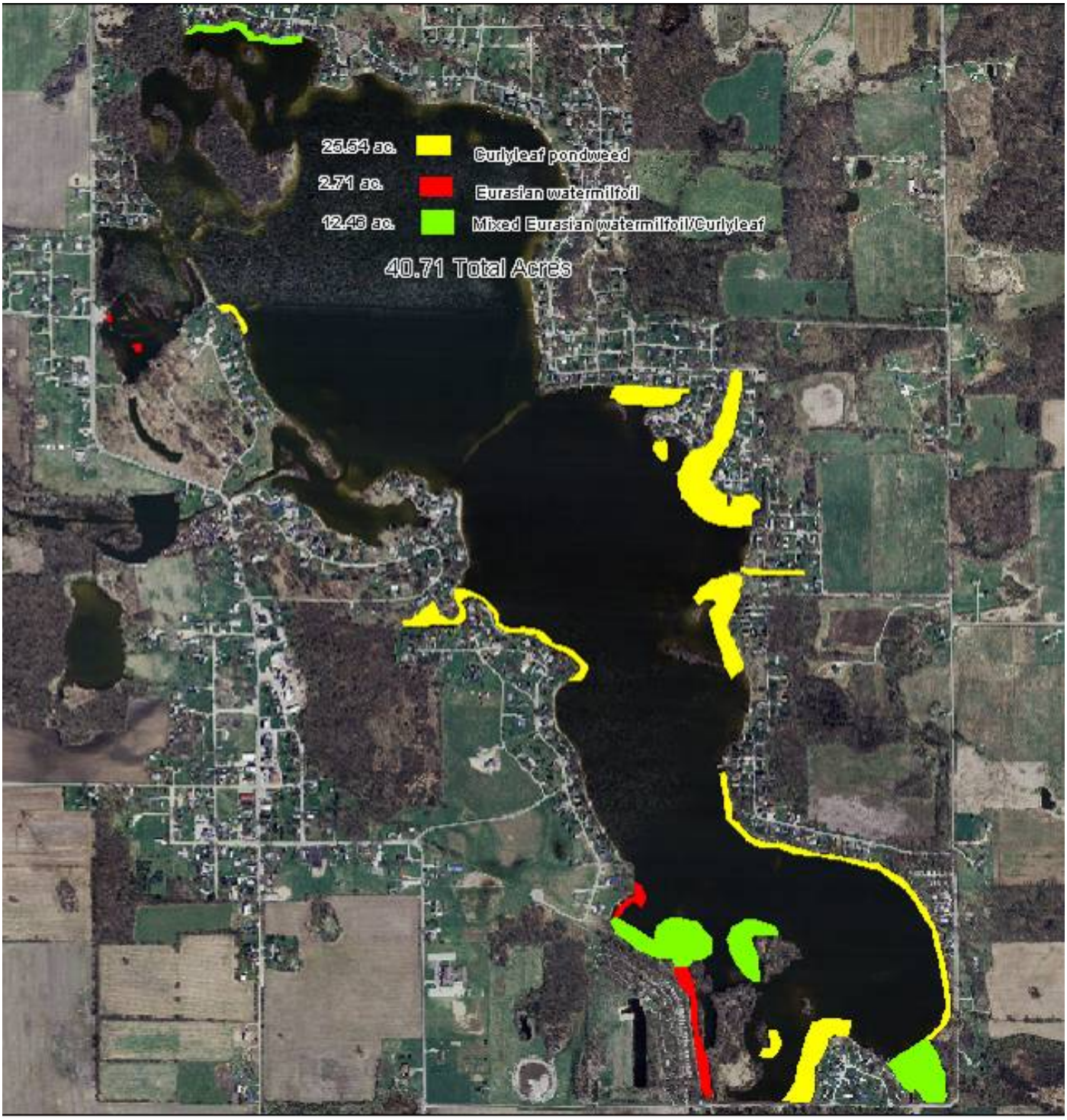


Figure 11 Dense Exotic Plant Growth on Big Turkey Lake 6/07

Descriptor	Big Turkey 6/9/07	range for 21 other Indiana lakes	mean for 21 other Indiana lakes
# Sampling sites	80		
Total number of species	12	1 to 17	8
Total number of native species	10	1 to 16	7
Mean number of species per site	2	.38 to 2.66	1.61
Species diversity index (SDI), 0-1 scale	.87	0.0 to .91	0.66
Aquatic Vegetation % frequency of Occurrence	88		
Secchi Depth	7		
Eurasian watermilfoil % Frequency of Occurrence	5		
Curlyleaf pondweed % Frequency of Occurrence	37.5		

Table 1 Plant Community Descriptors from the 6/9/07 Big Turkey Tier II Survey

Descriptor	Big Turkey 8/10,11/07	range for 21 other Indiana lakes	mean for 21 other Indiana lakes
# Sampling sites	80		
Total number of species	14	1 to 17	8
Total number of native species	13	1 to 16	7
Mean number of species per site	2.49	.38 to 2.66	1.61
Species diversity index (SDI), 0-1 scale	.90	0.0 to .91	0.66
Aquatic Vegetation % frequency of Occurrence	90		
Secchi Depth	7		
Eurasian watermilfoil % Frequency of Occurrence	5		
Curlyleaf pondweed % Frequency of Occurrence	27.5		

Table 2 Plant Community Descriptors from the 8/10,11/07 Big Turkey Lake Tier II Survey

Occurrence and Abundance of Submersed Aquatic Plants - Overall

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.16			
Date: 6/9/2007	Littoral sites with plants: 66	Mean natives / site: 1.58			
Littoral Depth (ft): 11.0	Number of species: 12	SE Mean natives / site: 0.13			
Littoral Sites: 73	Maximum species / site: 6	Species diversity: 0.87			
Total Sites: 80	Mean species / site: 2.01	Native diversity: 0.83			

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
POTCRI Curlyleaf	37.5	62.5	27.5	7.5	2.5	12.5
CERDEM Coontail	36.3	63.8	27.5	3.8	5.0	12.8
MYRHET Variable milfoil	31.3	68.8	18.8	6.3	6.3	13.8
STUPEC Sago pondweed	27.5	72.5	16.3	6.3	5.0	12.0
CHAR Chara	21.3	78.8	17.5	1.3	2.5	6.8
POTPUP Small pondweed	17.5	82.5	16.3	0.0	1.3	4.5
POTZOS Flatstem pondwee	7.5	92.5	6.3	0.0	1.3	2.5
MYRSPI Eurasian milfoil	5.0	95.0	3.8	0.0	1.3	2.0
NAJFLE Slender naiad	3.8	96.3	3.8	0.0	0.0	0.8
NAJMAR Spiny naiad	3.8	96.3	3.8	0.0	0.0	0.8
POTGRA Variable pondwee	3.8	96.3	3.8	0.0	0.0	0.8
UTRMAC Great bladderwort	3.8	96.3	3.8	0.0	0.0	0.8
POTPRA Whitestem pondw	1.3	98.8	0.0	0.0	1.3	1.3

Table 3 Overall Tier II Plant Data for the June Survey

Occurrence and Abundance of Submersed Aquatic Plants - 0 to 5 ft.

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.20			
Date: 6/9/2007	Littoral sites with plants: 37	Mean natives / site: 1.41			
Littoral Depth (ft): 11.0	Number of species: 11	SE Mean natives / site: 0.16			
Littoral Sites: 44	Maximum species / site: 5	Species diversity: 0.86			
Total Sites: 44	Mean species / site: 1.84	Native diversity: 0.84			

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
POTCRI Curlyleaf	38.6	61.4	31.8	4.5	2.3	11.4
STUPEC Sago pondweed	22.7	77.3	13.6	2.3	6.8	10.9
CERDEM Coontail	27.3	72.7	15.9	6.8	4.5	11.8
MYRHET Variable milfoil	29.5	70.5	18.2	4.5	6.8	13.2
CHAR Chara	22.7	77.3	15.9	2.3	4.5	9.1
POTPUP Small pondweed	18.2	81.8	15.9	0.0	2.3	5.5
POTZOS Flatstem pondwee	6.8	93.2	4.5	0.0	2.3	3.2
MYRSPI Eurasian milfoil	2.3	97.7	2.3	0.0	0.0	0.5
POTGRA Variable pondwee	4.5	95.5	4.5	0.0	0.0	0.9
NAJFLE Slender naiad	4.5	95.5	4.5	0.0	0.0	0.9
UTRMAC Great bladderwort	4.5	95.5	4.5	0.0	0.0	0.9
POTPRA Whitestem pondw	0.0	100.0	0.0	0.0	0.0	0.0
NAJMAR Spiny naiad	2.3	97.7	2.3	0.0	0.0	0.5

Table 4 0-5 Foot Contour Data for the June Survey

Occurrence and Abundance of Submersed Aquatic Plants - 5 to 10 ft.

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.30		
Date: 6/9/2007	Littoral sites with plants: 20	Mean natives / site: 1.95		
Littoral Depth (ft): 11.0	Number of species: 10	SE Mean natives / site: 0.21		
Littoral Sites: 21	Maximum species / site: 5	Species diversity: 0.86		
Total Sites: 21	Mean species / site: 2.43	Native diversity: 0.82		

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
CERDEM Coontail	52.4	47.6	52.4	0.0	0.0	10.5
MYRHET Variable milfoil	33.3	66.7	19.0	9.5	4.8	14.3
POTCRI Curlyleaf	38.1	61.9	19.0	14.3	4.8	17.1
STUPEC Sago pondweed	38.1	61.9	14.3	19.0	4.8	19.0
CHAR Chara	28.6	71.4	28.6	0.0	0.0	5.7
POTPUP Small pondweed	23.8	76.2	23.8	0.0	0.0	4.8
NAJMAR Spiny naiad	0.0	100.0	0.0	0.0	0.0	0.0
POTZOS Flatstem pondwee	9.5	90.5	9.5	0.0	0.0	1.9
MYRSPI Eurasian milfoil	9.5	90.5	9.5	0.0	0.0	1.9
NAJFLE Slender naiad	4.8	95.2	4.8	0.0	0.0	1.0
UTRMAC Great bladderwort	4.8	95.2	4.8	0.0	0.0	1.0

Table 5 5-10 Foot Plant Data for the June Survey

Occurrence and Abundance of Submersed Aquatic Plants - 10 to 15 ft.

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.37		
Date: 6/9/2007	Littoral sites with plants: 8	Mean natives / site: 1.20		
Littoral Depth (ft): 11.0	Number of species: 6	SE Mean natives / site: 0.25		
Littoral Sites: 3	Maximum species / site: 3	Species diversity: 0.78		
Total Sites: 10	Mean species / site: 1.50	Native diversity: 0.72		

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
CERDEM Coontail	50.0	50.0	30.0	0.0	20.0	26.0
POTCRI Curlyleaf	30.0	70.0	20.0	10.0	0.0	10.0
MYRHET Variable milfoil	30.0	70.0	20.0	0.0	10.0	14.0
POTPUP Small pondweed	10.0	90.0	10.0	0.0	0.0	2.0
CHAR Chara	0.0	100.0	0.0	0.0	0.0	0.0
MYRSPI Eurasian milfoil	0.0	100.0	0.0	0.0	0.0	0.0
NAJFLE Slender naiad	0.0	100.0	0.0	0.0	0.0	0.0
NAJMAR Spiny naiad	0.0	100.0	0.0	0.0	0.0	0.0

Table 6 10-15 Foot Contour Plant Data for the June Survey

Occurrence and Abundance of Submersed Aquatic Plants - Overall

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.18			
Date: 8/10/2007	Littoral sites with plants: 72	Mean natives / site: 1.86			
Littoral Depth (ft): 14.5	Number of species: 14	SE Mean natives / site: 0.15			
Littoral Sites: 73	Maximum species / site: 7	Species diversity: 0.90			
Total Sites: 80	Mean species / site: 2.49	Native diversity: 0.86			

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
CERDEM Coontail	31.3	68.8	16.3	0.0	15.0	18.3
NAJMAR Spiny naiad	30.0	70.0	8.8	5.0	16.3	21.0
NAJFLE Slender naiad	30.0	70.0	15.0	6.3	8.8	15.5
CHAR Chara	30.0	70.0	17.5	2.5	10.0	15.0
POTCRI Curlyleaf	27.5	72.5	22.5	3.8	1.3	8.0
POTPUP Small pondweed	25.0	75.0	12.5	3.8	8.8	13.5
STUPEC Sago pondweed	25.0	75.0	17.5	5.0	2.5	9.0
MYRHET Variable milfoil	23.8	76.3	16.3	1.3	6.3	10.3
POTZOS Flatstem pondwee	8.8	91.3	6.3	0.0	2.5	3.8
MYRSPI Eurasian milfoil	5.0	95.0	5.0	0.0	0.0	1.0
ZOSDUB Water stargrass	3.8	96.3	2.5	1.3	0.0	1.3
POTGRA Variable pondwee	3.8	96.3	3.8	0.0	0.0	0.8
ELOCAN Elodea	2.5	97.5	2.5	0.0	0.0	0.5
POTILL Illinois pondweed	1.3	98.8	1.3	0.0	0.0	0.3
POTRIC Richardson's pondv	1.3	98.8	1.3	0.0	0.0	0.3

Table 7 Overall Tier II Plant Data for the August Survey

Occurrence and Abundance of Submersed Aquatic Plants - 0 to 5 ft.

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.26			
Date: 8/10/2007	Littoral sites with plants: 42	Mean natives / site: 2.26			
Littoral Depth (ft): 14.5	Number of species: 13	SE Mean natives / site: 0.22			
Littoral Sites: 43	Maximum species / site: 7	Species diversity: 0.90			
Total Sites: 43	Mean species / site: 2.91	Native diversity: 0.86			

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
CHAR Chara	39.5	60.5	27.9	4.7	7.0	15.3
CERDEM Coontail	37.2	62.8	16.3	0.0	20.9	24.2
STUPEC Sago pondweed	34.9	65.1	27.9	4.7	2.3	10.7
MYRHET Variable milfoil	32.6	67.4	23.3	0.0	9.3	14.0
POTCRI Curlyleaf	32.6	67.4	27.9	4.7	0.0	8.4
NAJFLE Slender naiad	30.2	69.8	14.0	11.6	4.7	14.4
NAJMAR Spiny naiad	27.9	72.1	9.3	7.0	11.6	17.7
POTPUP Small pondweed	23.3	76.7	14.0	4.7	4.7	10.2
POTZOS Flatstem pondwee	9.3	90.7	9.3	0.0	0.0	1.9
ZOSDUB Water stargrass	7.0	93.0	4.7	2.3	0.0	2.3
POTGRA Variable pondwee	7.0	93.0	7.0	0.0	0.0	1.4
MYRSPI Eurasian milfoil	4.7	95.3	4.7	0.0	0.0	0.9
ELOCAN Elodea	2.3	97.7	2.3	0.0	0.0	0.5
POTILL Illinois pondweed	2.3	97.7	2.3	0.0	0.0	0.5

Table 8 0-5 Foot Contour Data for the August Tier II Plant Survey

Occurrence and Abundance of Submersed Aquatic Plants - 5 to 10 ft.

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.23			
Date: 8/10/2007	Littoral sites with plants: 26	Mean natives / site: 1.74			
Littoral Depth (ft): 14.5	Number of species: 11	SE Mean natives / site: 0.19			
Littoral Sites: 27	Maximum species / site: 5	Species diversity: 0.88			
Total Sites: 27	Mean species / site: 2.48	Native diversity: 0.84			

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
NAJFLE Slender naiad	40.7	59.3	22.2	0.0	18.5	23.0
NAJMAR Spiny naiad	37.0	63.0	11.1	3.7	22.2	26.7
POTPUP Small pondweed	33.3	66.7	14.8	3.7	14.8	20.0
CERDEM Coontail	33.3	66.7	22.2	0.0	11.1	15.6
POTCRI Curlyleaf	29.6	70.4	22.2	3.7	3.7	10.4
CHAR Chara	18.5	81.5	7.4	0.0	11.1	12.6
MYRHET Variable milfoil	14.8	85.2	7.4	3.7	3.7	7.4
STUPEC Sago pondweed	14.8	85.2	7.4	3.7	3.7	7.4
POTZOS Flatstem pondwee	11.1	88.9	3.7	0.0	7.4	8.1
MYRSPI Eurasian milfoil	7.4	92.6	7.4	0.0	0.0	1.5
ELOCAN Elodea	3.7	96.3	3.7	0.0	0.0	0.7
POTRIC Richardson's pondv	3.7	96.3	3.7	0.0	0.0	0.7

Table 9 5-10 Foot Contour Data for the August Tier II Survey

Occurrence and Abundance of Submersed Aquatic Plants - 10 to 15 ft.

Lake: Big Turkey	Secchi(ft): 7.0	SE Mean species / site: 0.33			
Date: 8/10/2007	Littoral sites with plants: 4	Mean natives / site: 0.50			
Littoral Depth (ft): 14.5	Number of species: 4	SE Mean natives / site: 0.22			
Littoral Sites: 9	Maximum species / site: 3	Species diversity: 0.78			
Total Sites: 10	Mean species / site: 0.70	Native diversity: 0.72			

	Frequency of	Score Frequency				
Species	**Occurrence**	**0**	**1**	**3**	**5**	**Dominance**
CHAR Chara	20.0	80.0	0.0	0.0	20.0	20.0
NAJMAR Spiny naiad	20.0	80.0	0.0	0.0	20.0	20.0
POTPUP Small pondweed	10.0	90.0	0.0	0.0	10.0	10.0
STUPEC Sago pondweed	10.0	90.0	0.0	10.0	0.0	6.0
MYRHET Variable milfoil	10.0	90.0	10.0	0.0	0.0	2.0
CERDEM Coontail	0.0	100.0	0.0	0.0	0.0	0.0
ELOCAN Elodea	0.0	100.0	0.0	0.0	0.0	0.0
MYRSPI Eurasian milfoil	0.0	100.0	0.0	0.0	0.0	0.0
NAJFLE Slender naiad	0.0	100.0	0.0	0.0	0.0	0.0

Table 10 10-15 Foot Contour Data for the August Tier II Survey

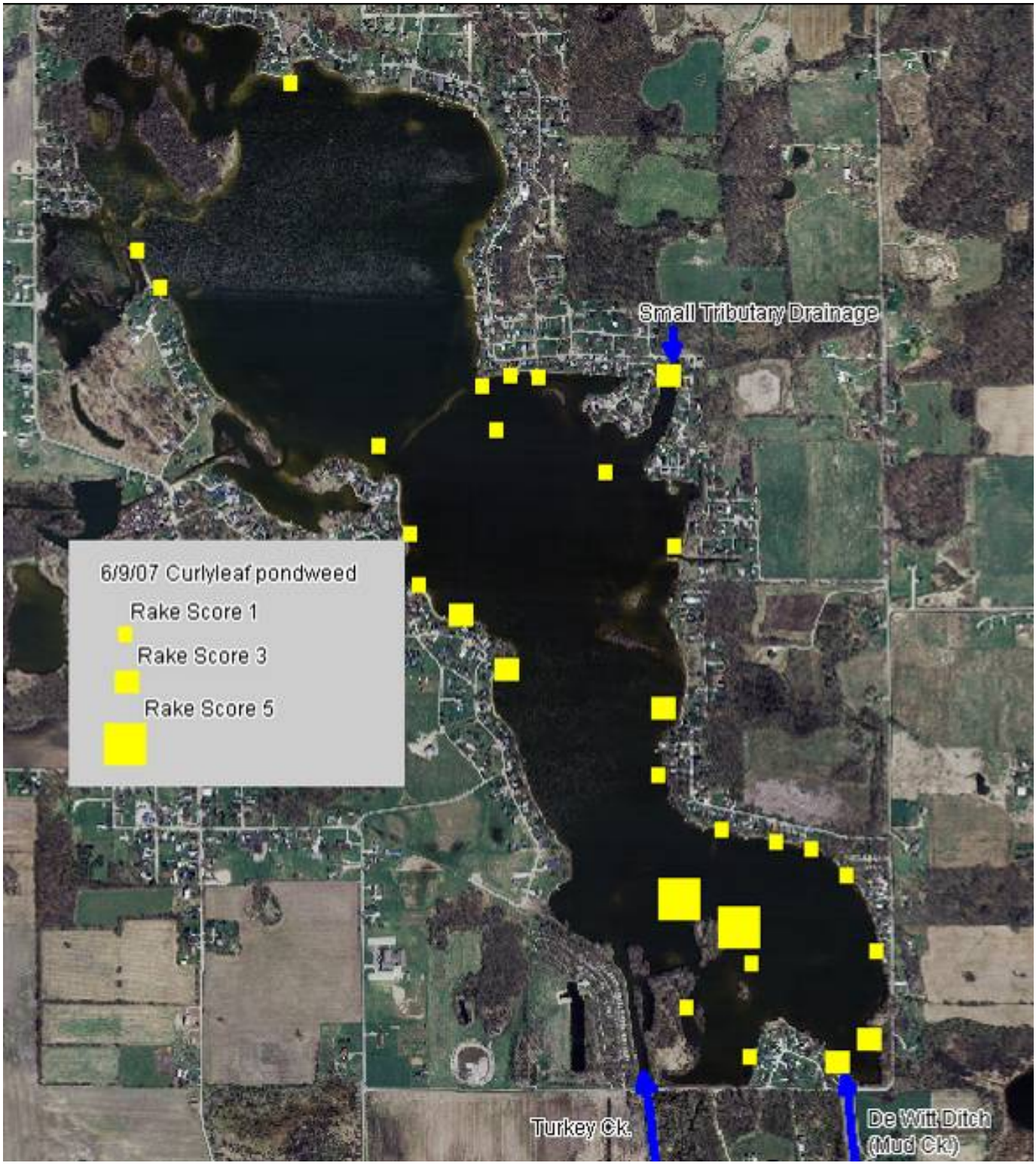


Figure 12 Curlyleaf Map for the Early Season Tier II Survey

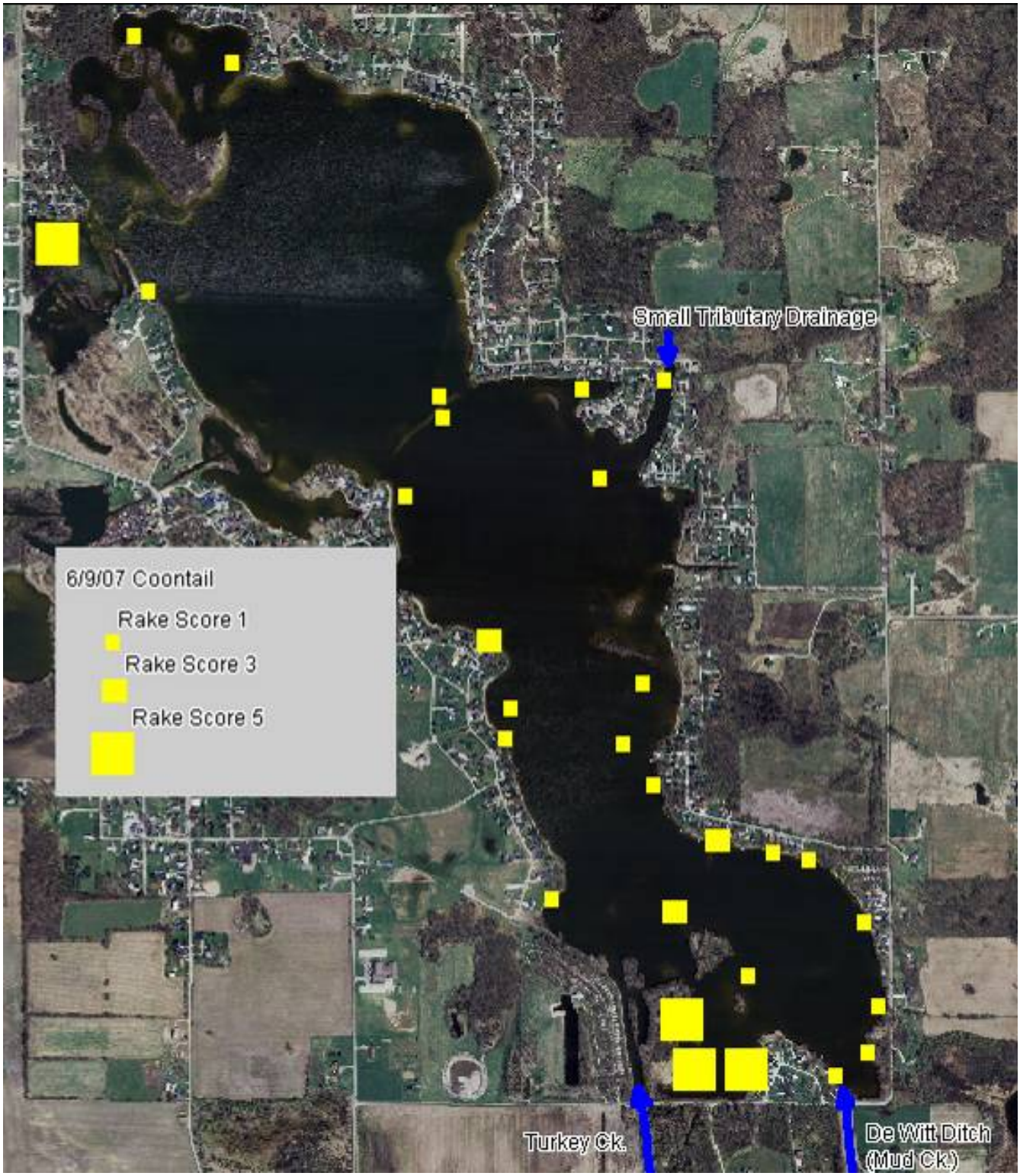


Figure 13 Coontail Map for the Early Season Tier II Survey

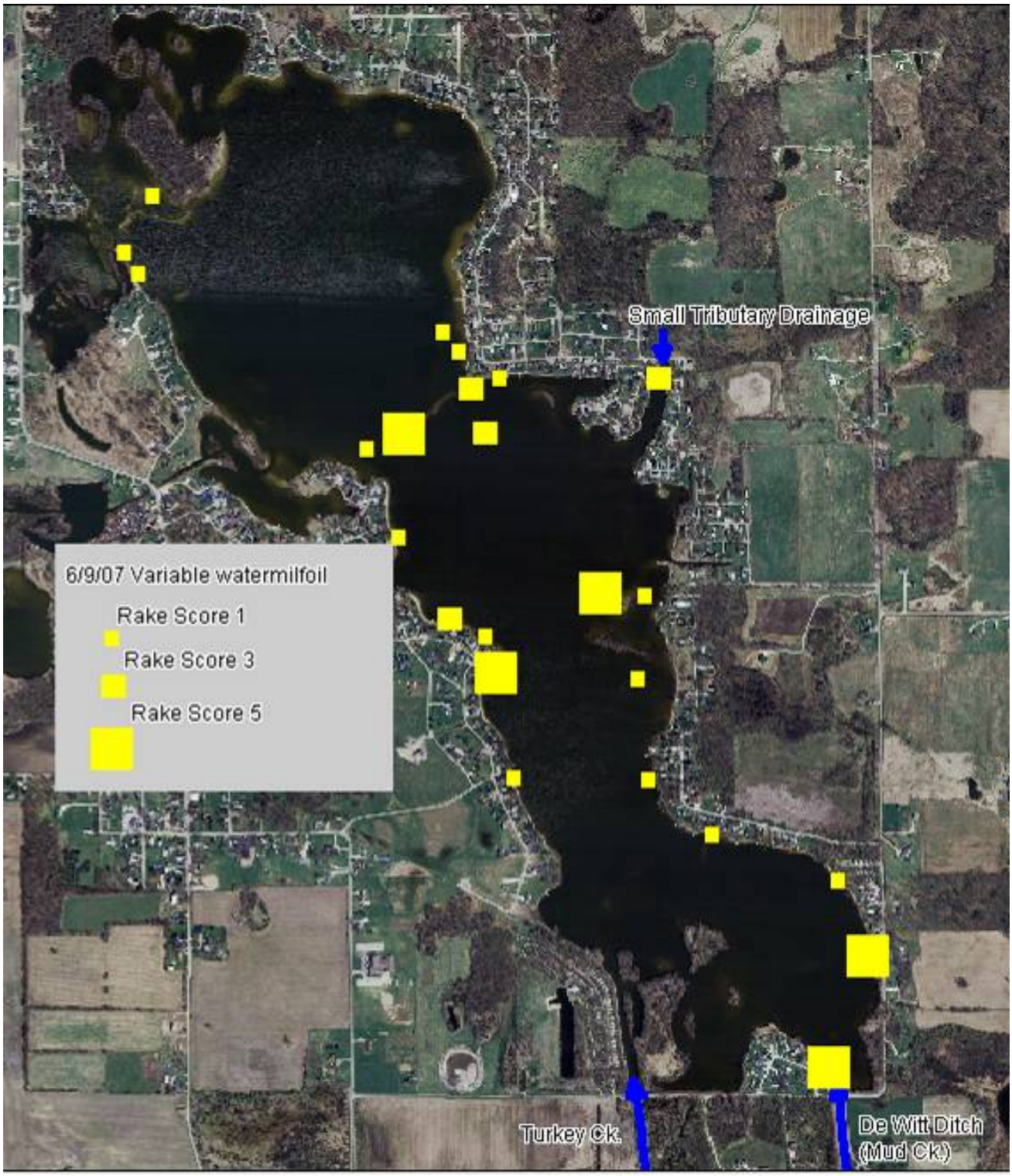


Figure 14 Variable watermilfoil Map for the Early Season Tier II Survey

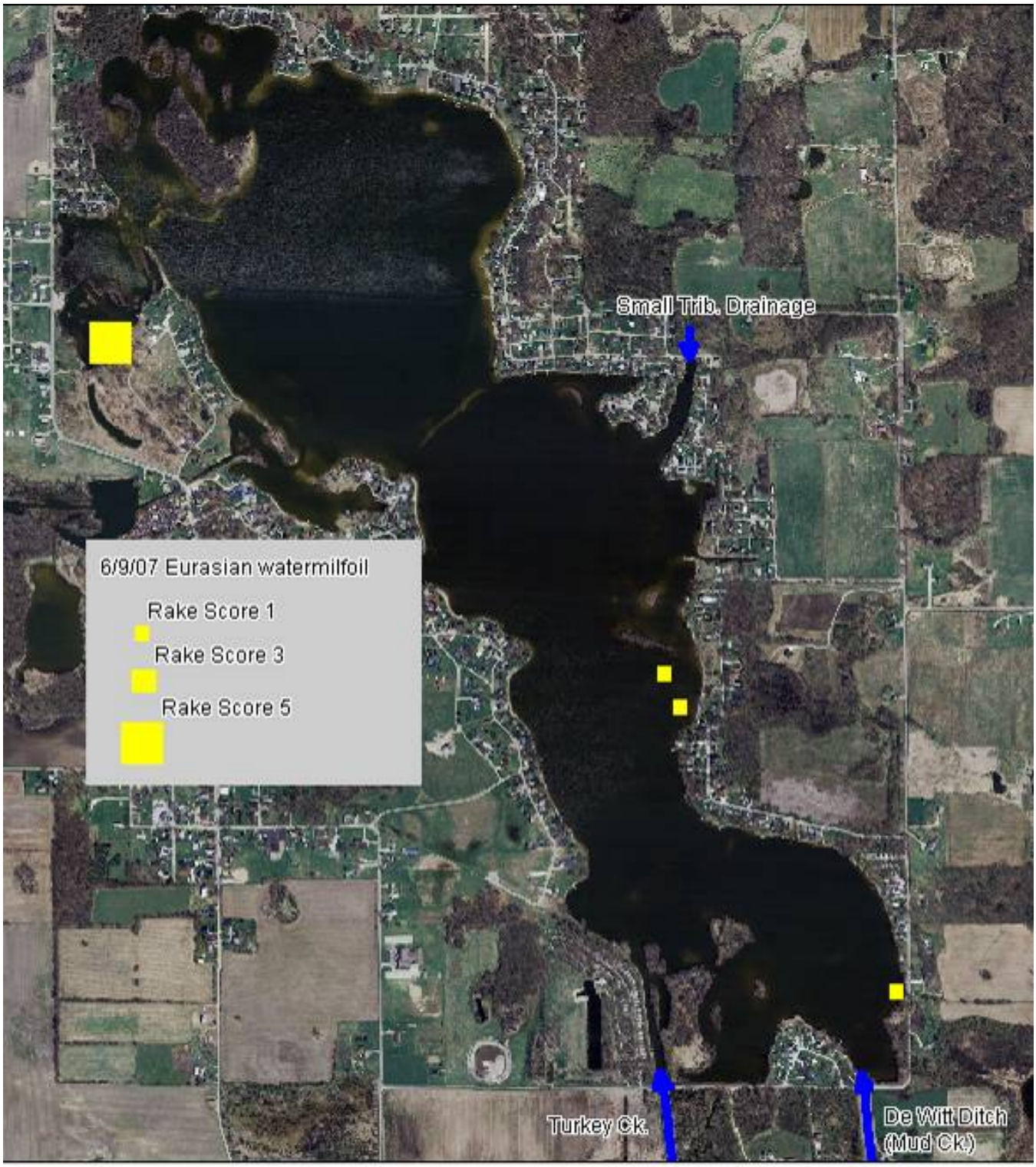


Figure 15 Eurasian watermilfoil Map for the Early Season Tier II Survey

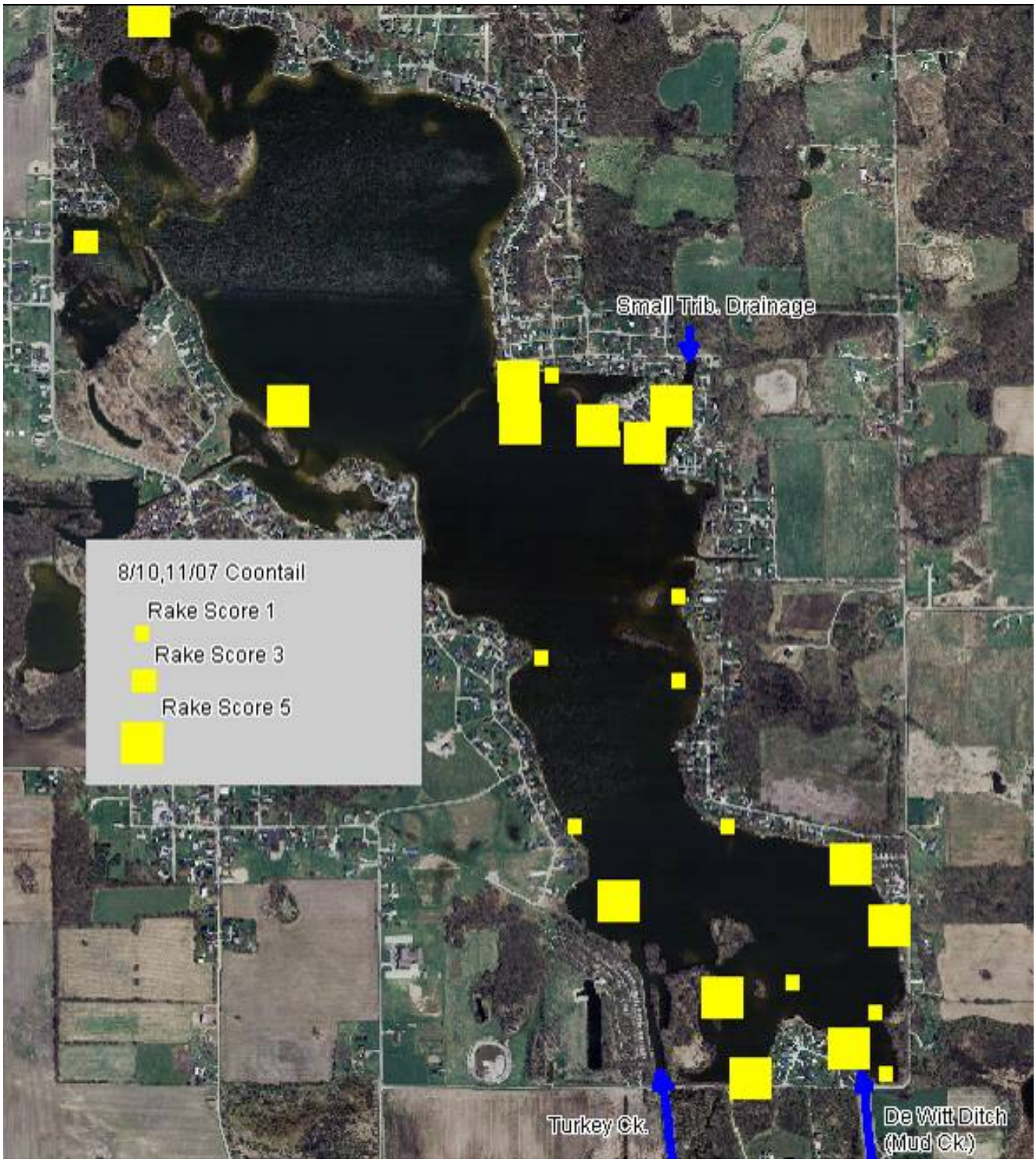


Figure 16 Coontail Map for the Late Season Tier II Survey

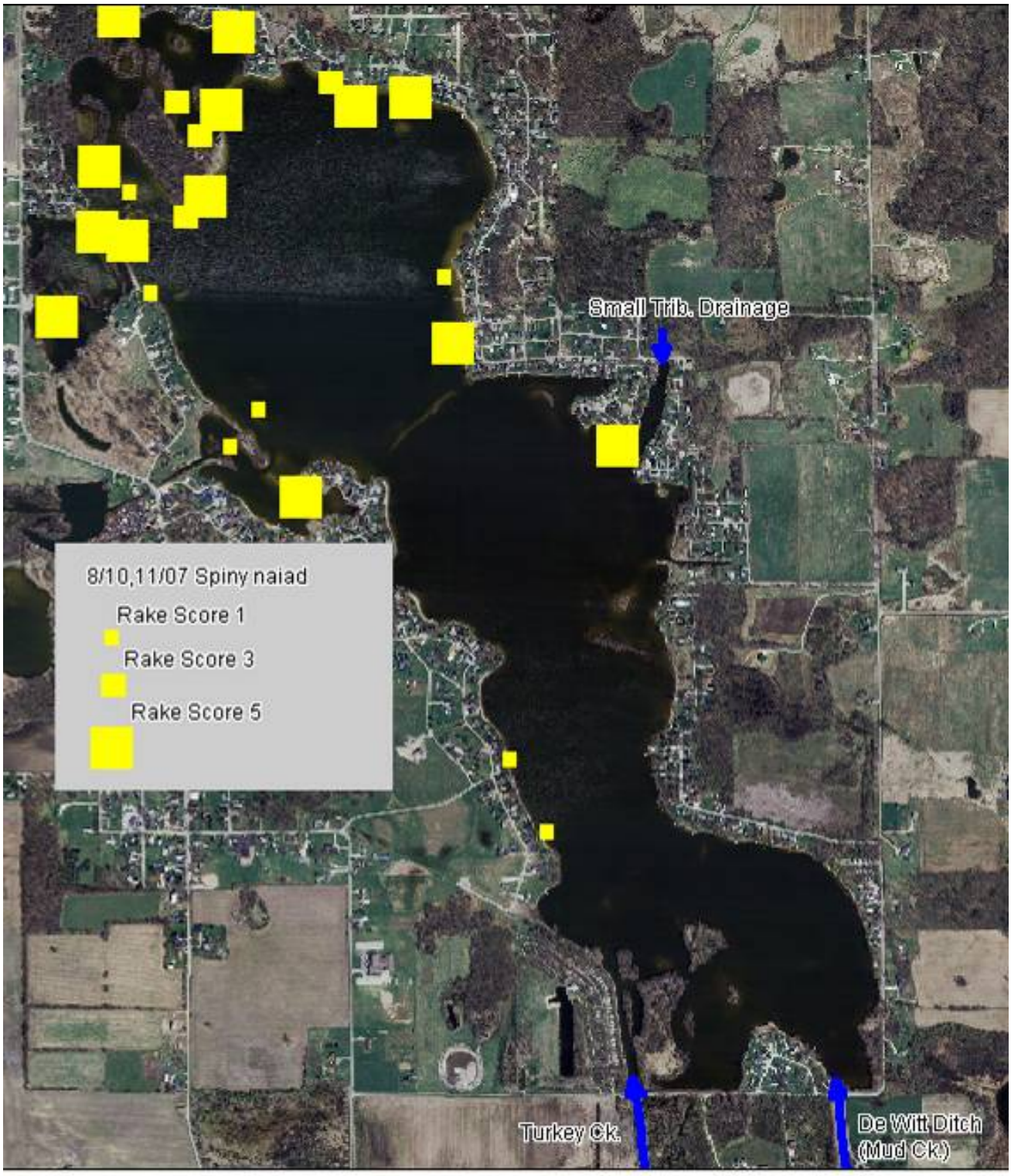


Figure 17 Spiny naiad Map for the Tier II Late Season Survey

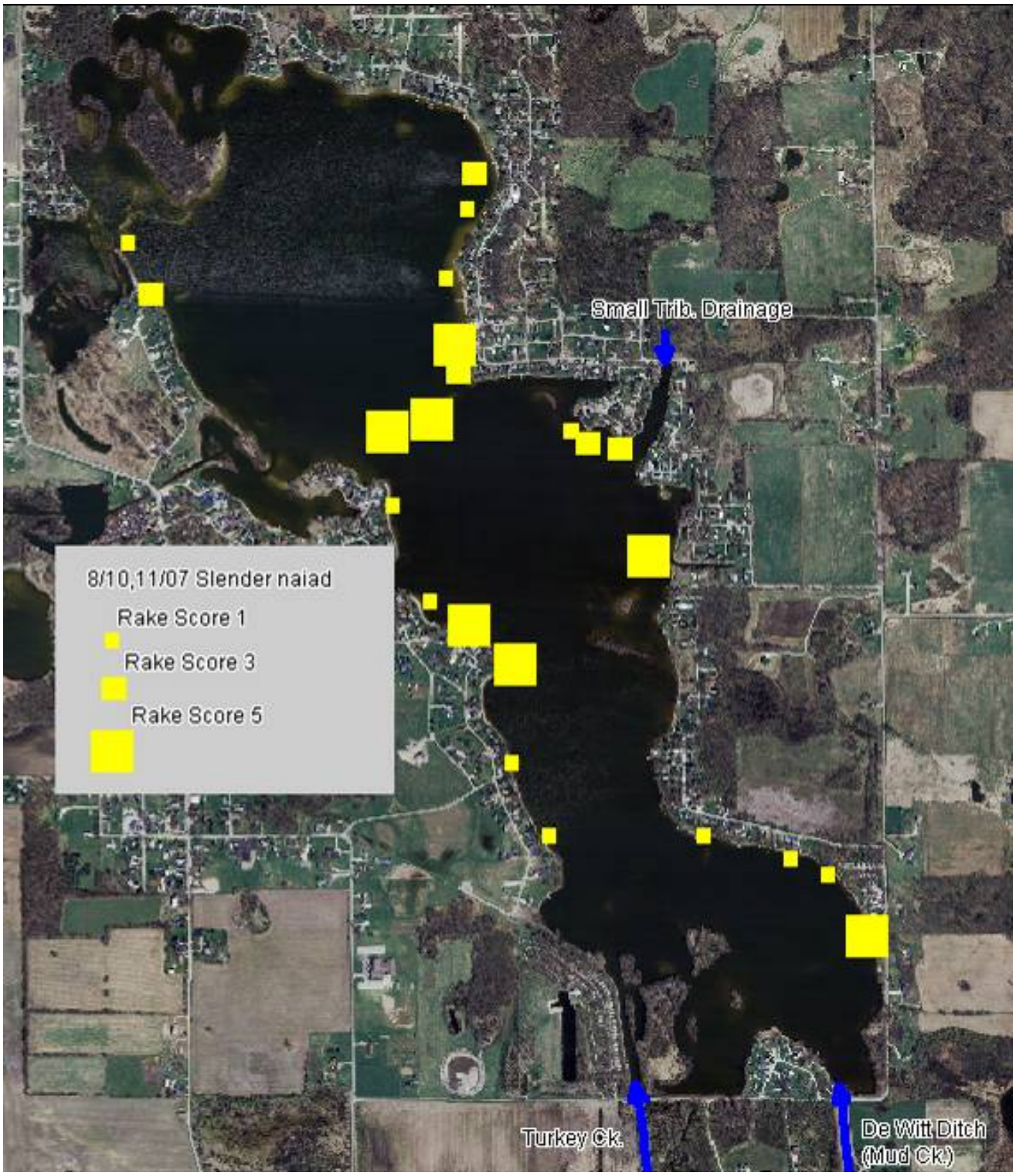


Figure 18 Slender naiad Map for the Late Season Tier II Survey

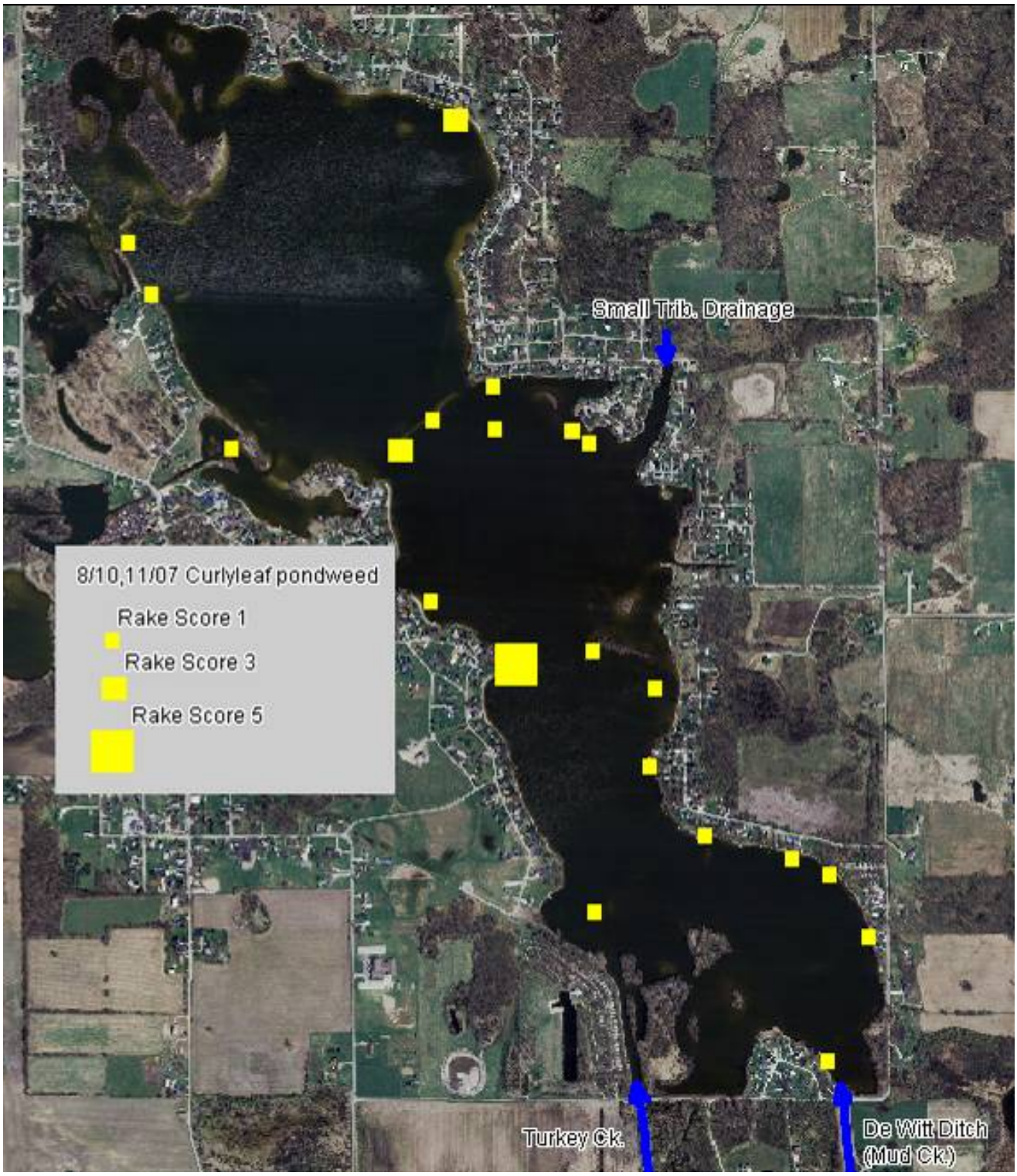


Figure 19 Curlyleaf pondweed Map for the Late Season Tier II Survey

Figure 20 Eurasian watermilfoil Map for the Late Season Tier II Survey

9.0 Aquatic Vegetation Management Alternatives

General Options for Controlling Invasive Exotic Aquatic Plants

•Insect Biological Control:

A North American Weevil *Euhrychiopsis lecontie*, may be associated with natural declines in Eurasian milfoil at northern lakes (Sheldon 1994, Bratager et al. 1996, Weinberg 1995). In recent years the weevils have been marketed and stocked as a biological control agent with varying results. Historically associated with the native milfoils, the insects are capable of grazing on Eurasian milfoil as well, while not affecting the majority of native vegetation. A control program involves breeding the weevils in captivity, collecting them and then physically attaching the insects to the target plants in the field. The stocked weevils sometimes produce a modest reduction in milfoil biomass among targeted plants during the first season. In most cases restocking must occur every year to maintain control, in many cases no reduction in plants is noted at all after stocking. Interest in the use of the milfoil weevils has been high. They are often viewed as a natural control method that will be less environmentally damaging than more effective forms of control. At present, the high cost and relatively low reductions in plant biomass associated with weevil stocking programs has severely limited their popularity as a control mechanism.

•Harvesting:

There are several models of machines produced for cutting and removal of aquatic vegetation from lakes. Contractors who own the machines generally hire on to cut plants on an hourly basis with organizations that can provide a set minimum hours of work to cover mobilization costs. Most harvesters are constructed like a floating combine. The floating machine is driven and steered with paddle wheels. An underwater cutting bar cuts plant stems and a driven belt carries the cuttings to the back of the machine where they are deposited in a hopper. When the machines hopper is full the machine operator offloads the aquatic cuttings in a designated area or into the back of a truck for disposal. One advantage of harvesting is the actual removal of plant material and associated nutrients from the lake. Unfortunately, only a very small percentage of a lakes nutrient load is invested in plant biomass at any given time. In most cases the cutting will have to be repeated each season and often multiple cuttings per season are needed to control plant regrowth. A major disadvantage of harvesters is the amount of biological disturbance introduced to the lake during the cutting process. Eurasian watermilfoil maintains the ability to recover very quickly from cutting. Native plants which cannot recover as readily from the harvesting encounter a selective disadvantage. The end result can be a shift in plant biomass away from more beneficial native plants, toward Eurasian watermilfoil. Whereas Eurasian milfoil can reproduce through fragmentation, the potential for free floating cut plants to spread growth by settling in other parts of the lake also must be considered. Aquatic plant cutters also tend to entrain a large number of small fish, turtles, and other aquatic organisms which will be removed from the lake if not screened out by the operator. Because of these problems weed harvesting has become subject to regulation and permitting by the Indiana Department of Natural Resources. Harvesters are often the only effective option for controlling excessive growths of stout native plants that do not respond well to other control methods. They are also often employed in areas where regulatory permitting excludes the use of pesticides.

•Control of Eurasian watermilfoil and Curly-leaf Pondweed with Aquatic Contact Herbicides:

Several aquatic contact herbicides are available for use in Indiana lakes. Aquatic pesticide applications on Indiana public lakes are subject to review and permitting on a seasonal basis with the Indiana Department of natural Resources. In addition aquatic applicators for hire must be licensed through the office of the Indiana State Chemist. In aquatic herbicide applications chemical products are typically dispersed over target plants as liquid or granular formulations using specialized boat-mounted equipment. Most contact herbicides function by eroding the cell membranes of plant tissue disrupting plant functioning. Control is usually achieved quickly with susceptible plant species often dropping out

in less than one week. Aquatic herbicide choices are somewhat limited as EPA approved products must not cause damage to untargeted organisms, provide a hazard to lake users, or leave harmful residues in the environment. Because of these requirements most contact herbicides have a short half-life in an aquatic environment, being lost to soil adhesion, photodegradation, or bacterial decomposition shortly after application. By both accident and design, most aquatic contact herbicides are selectively effective against obnoxious exotic species with Eurasian milfoil, and Curly-leaf pondweed being especially susceptible. Stout native species such as some of the larger native pondweeds and most of the native milfoils largely remain unaffected by marginal applications on larger lakes. This provides the advantage of allowing selective control, dropping out invasive exotics and leaving the native plant community to recover and capitalize on available light. Selective susceptibility needs to be considered when making herbicide choices so that appropriate plant community effects occur. Contact herbicides tend to leave plant root structures intact so regrowth often begins shortly after treatment. Multiple treatments can be needed in some cases to maintain full-season control. Use of some herbicides requires that lake activities such as swimming or lawn irrigation be restricted near the treatment area during a post treatment waiting period. Water-use restrictions generally apply within 100 feet of the application area. Waiting periods for swimming and other water-uses vary between zero and 120 days depending on the product used.

•Aquatic Plant Control with 2-4-D Granular Translocated Aquatic Herbicide:
Granular formulations of 2-4-D herbicide have been used for many years to control Eurasian watermilfoil. In lawn, agricultural, and aquatic applications 2-4-D is used to selectively control plants which are biologically classified as "broadleaves". Aquatic plants in this category include Eurasian and Native milfoils and Coontail *Ceratophyllum echinatum*. 2-4-D is a translocated or "systemic" aquatic herbicide. It is absorbed by target plants and transported through their vascular systems, affecting remote parts of the plant including the root structure. This offers the theoretical advantage of actually killing more plants and providing longer term control. Well-timed 2-4-D applications in some cases provide seasonal control of Eurasian watermilfoil with regrowth occurring the following season. Occasionally reapplication is needed within the same season. With milfoil infestations, 2-4-D offers the advantage of being highly selective for milfoil with the pondweeds and most other native plants remaining completely unaffected. Granular 2-4-D use typically restricts swimming near the treatment area for one day, and requires a waiting period on the use of lake water for lawn irrigation, so ornamental and garden plants will not be damaged. Granulars are useful in areas with water movement because granular carrier pellets settle into plant foliage or the lake bottom and bleed active ingredients off in a time-release manner, granting a longer plant contact time than is achievable with liquids.

•Aquatic Plant Control with Trichlopyr Translocated Aquatic Herbicide:
Available in a liquid formulation or granular flake (OTF) as Renovate 3® aquatic herbicide, trichlopyr offers broadleaf specific systemic control of aquatic plants in a liquid herbicide. This offers the advantage of easier handling and application over 2-4-D. Results have been similar to the use of 2-4-D. Improved application techniques and the use of adjuvants show some promise of possible providing multi-seasonal control with the use of Trichlopyr. The current labels allows the restricted use of dosed lake water to be adjusted in accordance with lake-water assay results, greatly reducing the time of restriction in most cases. The label application rates for Renovate 3® make deep water applications rather expensive when compared with label rates for granular 2,4-D applications.

•Aquatic Plant Control with Fluridone Translocated Aquatic Herbicide:
Two aquatic herbicide formulations containing fluridone are currently available under the trade names Avast!® and Sonar®. Fluridone is an extremely effective aquatic herbicide at very small concentrations in lakes and ponds, while it displays a relatively low toxicity to fish and mammals. Unlike most other aquatic herbicides it's also environmentally persistent, often remaining in the dosed waterbody in minute, but measurable amounts over the course of several months. Fluridone is absorbed by plant

shoots from water, and from hydrosoil by the roots of aquatic vascular plants. In susceptible plants, fluridone inhibits the formation of carotene. In the absence of carotene chlorophyll is rapidly photodegraded causing plants to become chlorotic (whiteish) and eventually drop out. Like many other herbicides fluridone is capable of a high degree of selective control at proper dosages. Within the assemblage of plants in most Indiana lakes, Curly-leaf pondweed and Eurasian watermilfoil are most susceptible. For control of Eurasian milfoil fluridone is introduced into a lake at the calculated rate of six to twelve parts-per-billion. Assays are often performed within the first two weeks after initial dosing to assess a hit or miss on a target concentration. A second dosage is often used to maintain the target concentration for a period of 60 to 90 days as the product is allowed to work. At a 6 PPB dosage rate fluridone is highly selective for Eurasian watermilfoil and Curly-leaf pondweed. Control typically lasts the entire season with occasional carryover effects during the second season. At dosages of 10 to 12 PPB Eurasian watermilfoil control is typically complete by the end of the first season and often extends through the second season, but a variety of native plants may be impacted. One major advantage of Fluridone use is its persistence and slow activity. During the extended treatment period the product mixes throughout the upper strata of the entire lake basin, allowing it to reach all exotic target plants in contact with the water. This also means that consideration must be given to possible impacts downstream from the target lake. Because of its slow rate of activity fluridone also offers the advantage of providing for gradual breakdown of target plants, providing a more gradual release of nutrients than faster acting herbicides. This decreases the chances of developing oxygen deficits or excessive algal blooms in shallow lakes. Because of the high cost of fluridone herbicides, their use is often reserved for lakes with extensive littoral areas showing profound mat-forming infestations and severely impaired recreational use. The only water-use restriction associated with fluridone is a wait on the use of lake water for lawn and garden irrigation of 14 to 30 days depending on dose rate.

•Aquatic Plant Control with Triploid Grass Carp (White Amur):
The Asiatic Grass Carp *Ctenopharyngodon idella* have become popular as an introduced exotic biological control for rooted aquatic plants in ponds and southern U.S. lakes. Grass Carp are native to river systems of Russia and China. The species was first imported to the southern United States in 1963. Like most biological controls herbivorous grass carp have remained extremely popular despite some problems associated with their use. Stocking of grass carp was initially illegal in many states including Indiana. Because grass carp are a possibly detrimental exotic species, resource managers feared a destructive establishment of viable wild populations. This process had already occurred with the common carp which remains a destructive influence in our aquatic habitats. Proponents of the plant-eating fish argued that viable breeding habitat for the carp was not present in the United States. That argument was refuted when viable reproduction was noted in the 1980's in tributaries to the Mississippi. When a technique was developed for producing genetically altered triploid grass carp stock with greatly reduced fertility, laws in many states including Indiana were changed to allow stocking of the sterile fish in private waters. The possibility still exists for fish producers to bypass the necessary hatchery process and market fertile fish. Illegally stocked fertile grass carp have been found in some locations. Use of any grass carp remains illegal in twelve states including Michigan. Despite remaining controversy, some regulatory agencies encourage their use in ponds and lakes publishing stocking guidelines and even offering the fish for sale. Grass carp have been introduced into thousands of private ponds and many larger reservoirs in the southern United States with mixed results. Often stockings in large waterbodies bring either complete eliminations of vegetation or very little decline at all (Cassani 1995). Grass Carp are selective feeders and unfortunately tend to prefer most native plant species over Eurasian watermilfoil. Results of grass carp stocking vary with the plant species assemblage present in stocked waters and variations in Lake Morphometry. In general, stocking at low rates can be expected to produce a shift in plant biomass away from preferred species food plants, toward unpreferred. At high stocking rates the fish will consume all rooted aquatic vegetation in the system. This causes a shift in plant biomass toward planktonic and filamentous algae as fish waste and feeding activity boosts lake nutrient levels. At sustained high numbers, the fish will consume

filamentous algae, emergent aquatic plants, and even terrestrial vegetation within their reach at the lake's edge. Shoreline erosion can become a problem when this occurs. At the end result of sustained high stocking rates lake plant biomass will be maintained in planktonic algae, which the fish are unable to utilize as a food source. This can obviously lead to water clarity problems and unstable oxygen levels, especially in the temperate northern U.S. Successful use of grass carp on ponds and in large southern lakes often trades water clarity for alleviation of rooted plant problems. This technique can be effectively employed where water clarity and high oxygen levels are not a priority. In the case of most Indiana natural lakes where water quality and clarity is a high priority, use of herbivorous fish as a management technique would not be wise or legal.

•Benthic Barriers for Aquatic Plant Control

Sheets of plastic or rubber material have been used to exclude aquatic plant growth. Usually owners of small ponds or swimming areas will employ this technique by placing the liner on the bottom and depositing sand or pea gravel on the liner. One drawback with this technique is the tendency for gasses to build up beneath impermeable liner material pushing it up from the bottom. This occurs as decomposition in the lake sediments produces hydrogen sulfide and carbon dioxide gasses. Using mesh liners or permeated liners can alleviate this problem somewhat, but obviously will allow plants to grow through the liner. Bottom liners also effectively exclude areas of benthic habitat and are generally not permitted by IDNR in public lakes for this reason.

Option	Benefits	Drawbacks
No Control	No dollar cost, No water-use restrictions	Further loss of plant diversity, degraded fish & wildlife value, possible Sportfish stunting, Impeded recreational use, aesthetic problems
Biocontrol Weevils	No swimming restrictions, No watering restrictions	Often ineffective, Cost prohibitive
Biocontrol Grass Carp	No water-use restrictions, possible multi-season control	Results not-predictable, illegal in Indiana public waters, may cause water clarity/quality problems, limited selectivity
Harvesting	No water-use restrictions, Removes some nutrients from lake	May hasten spread Eurasian milfoil through fragmentation and hydrosoil disturbance, Expensive, May result in regrowth within same season, Requires plant disposal site, Non-selective
Benthic liners	No water-use restrictions, possible multi-seasonal control	Impairs benthic habitat, Not generally permitted in Indiana Public Waters, Not feasible in deep water, Inherent maintenance problems
Aquatic Pesticides (2-4-D)	Highly selective control, Very effective	Intermediate expense, difficult application, Swimming and irrigation restrictions, Generally provides one season's control. In Big Turkey the non-target plants, Variable watermilfoil and Coontail may be affected.
Aquatic Pesticides(Renovate)	Highly selective control, Very effective	Expensive- materials expense, Swimming and irrigation restrictions, Generally provides one season's control, In Big Turkey the non-target plants, Variable watermilfoil and Coontail may be affected.
Aquatic Pesticides (Sonar a.s.)	Highly selective control, Very effective, Multi-seasonal control	Expensive product, irrigation restriction, possible damage to non-target vegetation. At Big Turkey Elodea *Elodea canadensis* is the non-target plant most susceptible.
Aquatic Pesticides (contact herbicides) (diquat dibromide or endothols)	Some selectivity, Very effective, fast acting, least expensive application	Generally provides on season's control, Possible regrowth in late season, Swimming, Irrigation, and possible fish consumption restrictions

Table 11 General Plant Management Alternatives, Drawbacks and Advantages

10.0 Public Involvement

The Big Turkey Lake Association annually holds board meetings on the third Thursday of each month as well as a general meeting in May and a second in general meeting in September. Aquatic Plant management and the LARE program was discussed at a May meeting of the Big Turkey Lake association in 2007. Most attendees were lake property owners. Two IDNR Conservation officers were also present. A public meeting for Big Turkey Lake's Plant Plan Development was incorporated into the second regular association meeting on September 1, 2007 at a local neighborhood's meeting hall. The meeting was extremely well attended with approximately 75 people present. This represents typical meeting attendance at Big Turkey. Information about the lake's aquatic plant management plan was presented by Aquatic Enhancement & Survey, Inc. at the September meeting. Survey results indicated that attendees were Big Turkey Lake property owners and their families. A discussion was held about the status and goals of the Big Turkey Lake Plant Management Plan and opportunity was provided for lake residents to ask questions and provide input regarding plant management, the spread of invasive species, and water-use restrictions that may be involved with treatment. The Lake User Survey below was distributed to those present, filled out, and collected. Forty-five surveys were collected. All respondents indicated that they were lake property owners. When asked how long they had resided at the lake 17 respondents indicated they were 20+ year residents, 11 were 0-5 year, 10 were 6-10 year residents and seven were 11-20 year residents. All were association members. Forty four indicated that the growth of aquatic plants had detracted from their enjoyment of the lake at some point, one said it had not. When asked to mark ways in which they use the lake all 45 respondents marked boating, all 45 marked swimming, 42 marked "enjoy the view and atmosphere", 30 marked fishing, 26 marked "viewing wildlife", and six marked that they used the lake for irrigation. When asked whether Big Turkey Lake contained aquatic plants in nuisance quantities at the current time all 45 respondents marked yes. When asked whether they felt that the level of aquatic vegetation at the lake affects their property value all respondents indicated that it did. All 45 respondents also said they were in favor of vegetation control at the lake. Respondents were presented a list of seven common lake problems and asked to mark which apply to Big Turkey. Forty four respondents marked "too many plants" as a problem, 40 marked "dredging needed", 36 marked Canada geese, 29 indicated "poor water clarity", 16 marked that additional speed enforcement was needed, 8 marked "excessive boat traffic", and two indicated "too much fishing" as a problem. Big Turkey Lake appears to be unusual in the unanimity of sentiment towards reducing the amount of aquatic vegetation present in the lake. Because poor water clarity also ranked relatively high as an indicated problem (64 percent), management at Big Turkey will need to consider implications for water quality that can go along with plant management and continue with efforts to improve the watershed. The interest and motivation toward proceeding with management of exotic plants at Big Turkey is extremely high and the residents have expressed an open willingness to work toward the goals associated with their plant management plan.

Big Turkey Lake User Survey 9/1/07

1. Are you a Big Turkey Lake property owner? Yes_____ No_____

2. How many years have you been at the lake? (circle one) 0-5 years
6-10 years
11-20 years
More than 20 years

3. Has the growth of aquatic plants on Big Turkey Lake ever negatively affected your enjoyment of the lake? Yes_____ No_____

4. How do you use the lake? (mark all that apply)
___Swimming ___Irrigation (including lawn) ___Enjoy View and Atmosphere
___Boating ___Fishing _____View Wildlife
Other _____

5. Do you feel that Big Turkey has Aquatic plants in nuisance quantities at this time (2007)?
Yes ___ No ___

6. Do you feel the level of vegetation in the lake can negatively affect your property value?
Yes ___ No ___

7. Are you in favor of your lake association initiating efforts to control vegetation on the lake?
Yes ___ No ___

8. Are you a member of your lake association? Yes_____ No_____

9. Mark any of these you think are problems on your lake:
___ Too much fishing
___ Canada Geese
___ Excessive boat traffic
___ Dredging needed
___ Too many aquatic plants
___ Not enough aquatic plants
___ Poor water clarity
___ Additional Speed enforcement needed

Other_____

Please add any additional comments on the back:
□ Check here if commenting on the back

11.0 Public Education

The Big Turkey Lake Association should set reasonable goals for increasing awareness among lake users about lake health issues. The association newsletter and spring and fall association meetings can serve as the primary vehicles for disseminating information. Big Turkey Lake Association meetings are relatively well attended with approximately 75 people present. Big Turkey Lake contains approximately 267 lakeside dwellings (and many more with deeded access). Assuming two adult residents per dwelling the meeting attendance would represent about 14 percent of adult lakeside residents. It may be possible to reach more of these lake users through the newsletter circulation or further boosting meeting attendance. An association website might be another way that relevant information can be shared. The following areas should be addressed:

●Prevention of the spread of Exotic Invasive Aquatic and Wetland Species

An effort should be made to make lake users aware that their own boat trailers may have introduced Curlyleaf pondweed or Eurasian watermilfoil to Big Turkey Lake or could spread these plants to other lakes if plant material is not removed. Basic plant identification should be addressed so new invasive species appearing can be spotted early on. Important information is presented in the next report section on Hydrilla *Hydrilla verticillata,* an invasive aquatic plant that is new to Indiana.

●Prevention of lake nutrient enrichment.

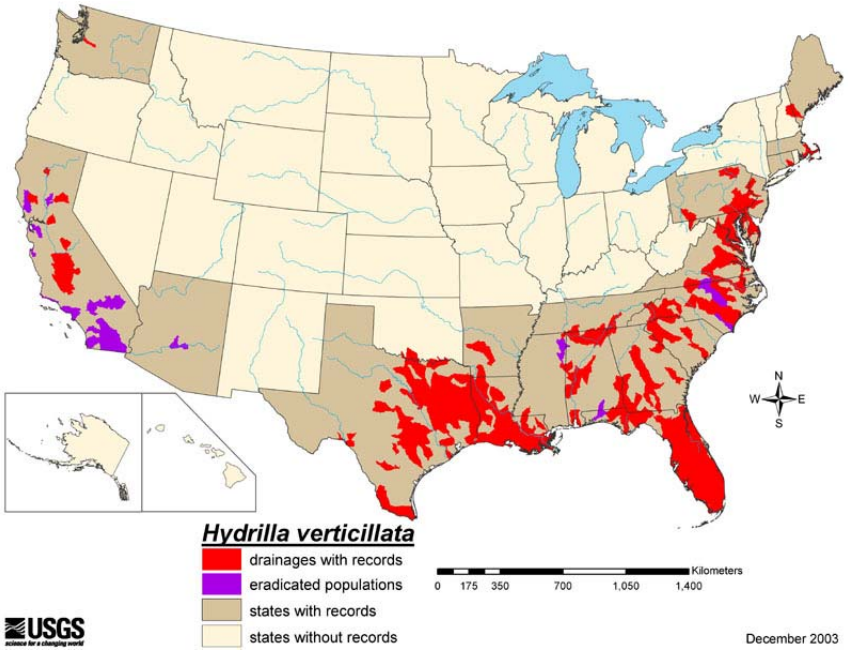
An effort should be made to encourage all lake residents to switch to no-phosphorus lawn fertilizers. Residents should also be made aware that soils lost through erosion in the watershed carry nutrients into the lake's waters as do sediments mobilized from the lake's bottom and shoreline by watercraft. Area residents should be aware of proper erosion control techniques at construction sites within the watershed.

●Expectations and water use restrictions associated with Plant Management

Residents should be made aware that LARE funds are intended to address only Exotic species of aquatic plants and control of plants will not occur throughout the whole lake. It is also important that residents understand and obey the posted water use restrictions associated with any chemical treatments performed.

11.1 Hydrilla and its implications for Big Turkey Lake

Keeping lake residents and users aware of the possibility of bringing in new invasive species on watercraft trailers will be especially important now that Hydrilla has been found in Indiana. Hydrilla *Hydrilla verticillata* is an invasive submersed aquatic plant thought to be native to Africa, Australia, and parts of Asia. As a hearty growing plant Hydrilla was used in aquariums and this led to its introduction into Florida waters in 1960. Since then Hydrilla has spread to become the single most problematic plant in the United States. (See USGS map below) In Florida alone millions are spent in controlling the growth of Hydrilla each year. The potential exists for the same type of damage on Indiana waterways if Hydrilla is allowed to spread. Like many invasive aquatic plants Hydrilla can form dense surface mats depriving native plant communities of light, decreasing plant community diversity, and causing serious impairment of recreational activities including fishing, swimming, and boating.



Known occurrences of Hydrilla in the U.S. in 2003. From the USGS website, http://nas.er.usgs.gov/taxgroup/plants/docs/hy_verti.html

Hydrilla mats clog the surface of Lake Conroe Texas. Photo courtesy of Earl Chilton, Texas Parks and Wildlife Department

Hydrilla can spread by fragmentation or the production of seeds, tubers (root structures), or turions (seed-like plant buds). Because of the potential for spread through fragmentation, plant material hitching a ride on watercraft trailers is probably a major mechanism of introduction. Tubers and turions can be very hearty, surviving dry periods or herbicide treatments and remaining hidden in the lake bottom for extended periods of time. Because of these characteristics great ecological damage and recreational impairment can occur in

watersheds colonized by Hydrilla. In 2006 Hydrilla was discovered in Lake Manitou and its outlet stream in Rochester Indiana (Fulton County). This is the first known occurrence of this plant in the Midwest. The Indiana Department of Natural Resources has devised a plan for eradicating and controlling the Hydrilla to prevent spread to other water bodies. Checks of other lakes in close proximity to Lake Manitou have not located any Hydrilla, so it is possible that the plant is only in and immediately downstream of Lake Manitou at this time. However, it's also possible that other lakes contain young Hydrilla infestations that have yet to be recognized so it's important that associations and lake residents learn to identify this plant. Acting early in spotting Hydrilla can help prevent spread and ultimately save a huge cost to the ecology and recreational value of Indiana lakes. At some point other infestations may occur as a result of plants being transported to Indiana from out-of-state. Whereas Big Turkey Lake is a popular boating and sportfishing destination, there is a definite possibility that this plant could appear in the Lake in the future. Information on Hydrilla identification should be presented to the Lake users at meetings as a regular part of the lake resident educational program.

Hydrilla is similar in appearance to the native plant Elodea and also Brazilian elodea, an exotic (also recently found in Indiana). It forms long stems containing many whorls of short leaves. Photo Courtesy of Dr. John H. Rodgers, Jr.

11.1.1 Hydrilla Identification

Hydrilla strongly resembles the native aquatic plant Elodea *Elodea canadensis* and the introduced species Brazilian elodea *Egeria Densa.* Both these species can be found in Indiana although the occurrence of Brazilian elodea has been very limited thus far. Native Elodea is part of the Big Turkey Lake plant community. Hydrilla is a long slender plant that sometimes branches and has short leaves arranged around the stem in a star-like (whorled) pattern. Characteristics which differentiate Hydrilla from Elodea and Brazilian Elodea include a typical leaf count of five in the whorl. Brazillian elodea typically has four to six leaves but never

three, and native Elodea usually has three. (fig 31) Small teeth are also present on the midrib of Hydrilla leaves and may give the plant a “rough” feel. Hydrilla also has small serrations along the leaf edges (fig 32). Another distinguishing characteristic of Hydrilla is the presence of tubers (.2 to .4 inch long off-white structures attached to the root) (fig 33).

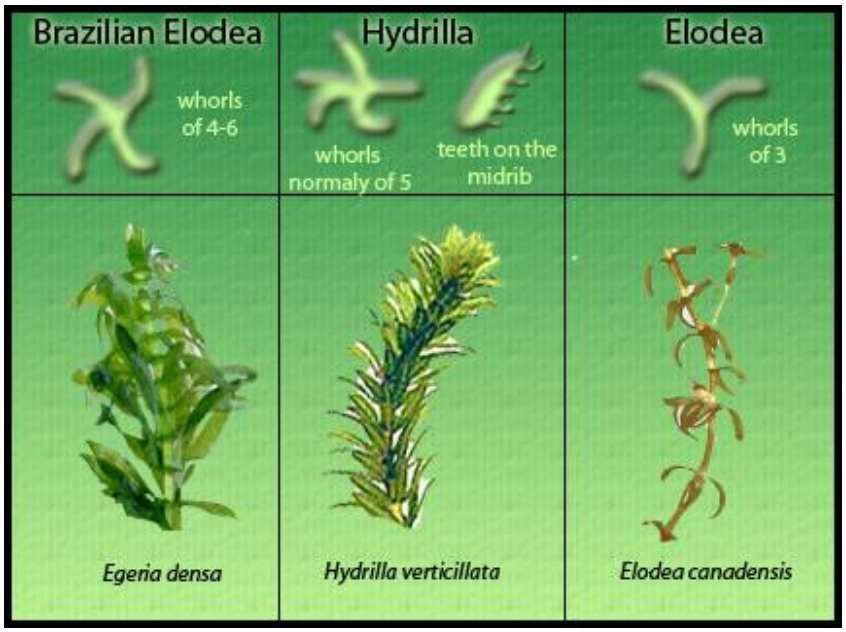


Fig. 1 Brazilian elodea has a typical leaf count of 4-6, while Hydrilla's is usually 5, and Elodea's 3. Drawing courtesy of Rob Nelson at ExploreBiodiversity.com

Fig. 2 Edges of Hydrilla leaves have fine serrations visible upon close examination. Photo Courtesy of Dr. John H. Rodgers, Jr.

Fig. 3 Hydrilla plants with tubers attached. Photo courtesy of King County Natural Resources and Parks, Water and Land Resources Division.

Anyone noting the presence of Hydrilla or Brazilian elodea is asked to immediately contact Doug Keller, Invasive species coordinator for the Indiana Department of Natural Resources at 317-234-3883, email: **dkeller@dnr.in.gov**. If you have questions about the identity of aquatic plants found, photos of the plants can be e-mailed to Doug for basic identification to determine if further action is required. More information on stopping the spread of invasive aquatic species is available online at **http://www.protectyourwaters.net/**

12.0 Integrated Management Action Strategy

Exotic plant management at Big Turkey should take an approach consisting of three tiers of action working toward this plans primary goals:

Tier 1. Nutrient and Sediment control.
The Big Turkey Lake Association should continue with ongoing efforts to address nutrient and sediment sources in the watershed, stopping these pollutants at their source.

Tier 2. Public Education.
The above educational points can potentially prevent a very costly infestation of new exotic plants and animals at Big Turkey Lake saving resources that can be utilized to address current problems.

Tier 3. Exotic Plant Control.
Addressing the submersed aquatic non-native plants present at Big Turkey Lake on a lakewide basis with EPA approved aquatic pesticides and monitoring results closely can potentially limit their spread while providing relief to lake users. Treatment regime detail is provided in the budget and timeline information in the next section. Reasonable success benchmarks for the applications will be a 5% or less occurrence of Curlyleaf and 5% or less occurrence of Eurasian milfoil in the July Tier II Survey.

13.0 Project Budget & Timeline

2008 Season ●**Success Benchmarks:** 5% or less occurrence of Curlyleaf and 5% or less occurrence of Eurasian milfoil in July Tier II Survey			
Month	**Activity**	**Acreage**	**Cost Estimate**
April	Map Curlyleaf pondweed And Eurasian watermilfoil growth		1000.00
April/May (H20 Temp. approx. 55 or shortly after emergence)	Treat Curlyleaf pondweed as needed (.5 ppm Aquathol K)	38	12540.00
May	Eurasian treatment on main lake as needed (2,4-D granular)	16	6656.00
July	Eurasian re-treatment as needed (2,4-D granular)	16	6656.00
July	Tier II Survey		1900.00
As arranged	Public Meeting		350.00
October/November	Permit Meeting		200.00
December	Plan Update Document Due		2000.00
	Total Cost, Pesticide Applications		**$25852.00**
	Total Cost, Consultant		**$5450.00**
	Total		**$31302.00**

2009 Season			
Month	**Activity**	**Acreage**	**Cost Estimate**
April	Map Curlyleaf pondweed And Eurasian watermilfoil growth		1000.00
April/May (H20 Temp. approx. 55 or shortly after emergence)	Treat Curlyleaf pondweed as needed (.5 ppm Aquathol K)	38	12540.00
May	Eurasian treatment on main lake as needed (2,4-D granular)	16	6656.00
July	Eurasian re-treatment as needed (2,4-D granular)	16	6656.00
July	Tier II Survey		1900.00
As arranged	Public Meeting		350.00
October/November	Permit Meeting		200.00
December	Plan Update Document Due		2000.00
	Total Cost, Pesticide Applications		**$25852.00**
	Total Cost, Consultant		**$5450.00**
	Total		**$31302.00**

2010 Season			
Month	**Activity**	**Acreage**	**Cost Estimate**
April	Map Curlyleaf pondweed And Eurasian watermilfoil growth		1000.00
April/May (H20 Temp. approx. 55 or shortly after emergence)	Treat Curlyleaf pondweed as needed (.5 ppm Aquathol K)	38	12540.00
May	Eurasian treatment on main lake as needed (2,4-D granular)	16	6656.00
July	Eurasian re-treatment as needed (2,4-D granular)	16	6656.00
July	Tier II Survey		1900.00
As arranged	Public Meeting		350.00
October/November	Permit Meeting		200.00
December	Plan Update Document Due		2000.00
	Total Cost, Pesticide Applications		**$25852.00**
	Total Cost, Consultant		**$5450.00**
	Total		**$31302.00**

2011 Season			
Month	**Activity**	**Acreage**	**Cost Estimate**
April	Map Curlyleaf pondweed And Eurasian watermilfoil growth		1000.00
April/May (H20 Temp. approx. 55 or shortly after emergence)	Treat Curlyleaf pondweed as needed (.5 ppm Aquathol K)	38	12540.00
May	Eurasian treatment on main lake as needed (2,4-D granular)	16	6656.00
July	Eurasian re-treatment as needed (2,4-D granular)	16	6656.00
July	Tier II Survey		1900.00
As arranged	Public Meeting		350.00
October/November	Permit Meeting		200.00
December	Plan Update Document Due		2000.00
	Total Cost, Pesticide Applications		**$25852.00**
	Total Cost, Consultant		**$5450.00**
	Total		**$31302.00**

14.0 Monitoring and Plan Update Procedures

The Big Turkey Lake Aquatic Plant Management Program should be monitored and updated on an annual basis. Monitoring will consist of monitoring not only the lake's plant community but the thoughts and opinions of the lakes users. To monitor the lake's plants exotic growth will be remapped each spring and compared with the previous season's growth pattern. A tier II survey in the late season after treatment has been initiated will serve to characterize the lake's overall plant community statistically and also gage if treatment bench marks have been attained. If treatment response bench marks are not attained changes in the treatment timing, chemical used, or integrated approach will all be options for setting a new course toward success. To monitor the thoughts and opinions of lake users at least one public meeting should be held annually and a survey distributed. An open forum at the meeting should exist to allow for discussion of water-use restrictions associated with treatments, new problems arising at the lake, or treatment effectiveness. Updates on program progress and developments should be issued in the Big Turkey Lake Association Newsletter.

15.0 Literature Cited

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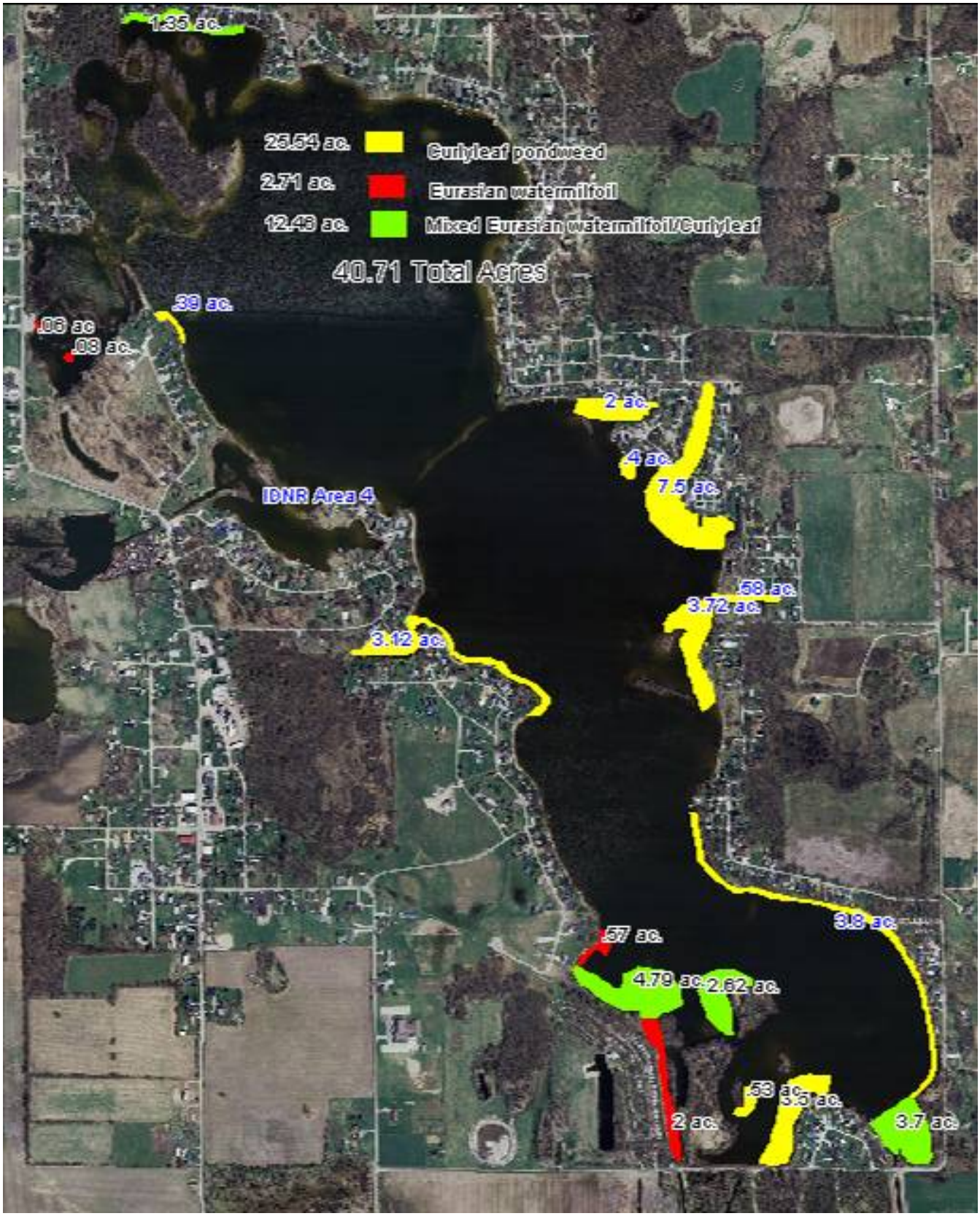
16.0 Appendices

Appendix 16.1
Plant Survey Data Sheets

Appendix 16.2
Treatment Data and Maps


1.35 ac.
25.54 ac.
Curlyleaf pondweed
2.71 ac.
Eurasian watermilfoil
12.48 ac.
Mixed Eurasian watermilfoil/Curlyleaf
40.71 Total Acres
.39 ac.
.06 ac
.08 ac.
2 ac.
.4 ac.
7.5 ac.
IDNR Area 4
.58 ac.
3.72 ac.
3.12 ac.
.57 ac.
3.8 ac.
4.79 ac.
2.62 ac.
.53 ac.
2 ac.
3.7 ac.

Appendix 16.3
IDNR Vegetation Permit Application

Appendix 16.4
Pesticide Use Restrictions / Pesticide Labels

Appendix 16.5
Resources For Aquatic Vegetation Management
(funding and technical assistance)

Appendix 16.6
State Regulations Relevant to Aquatic Plant Management